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THE POPULAR
Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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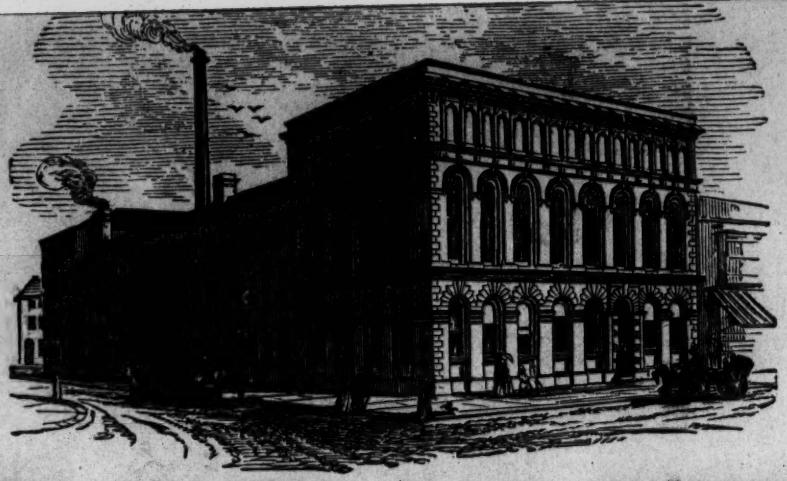

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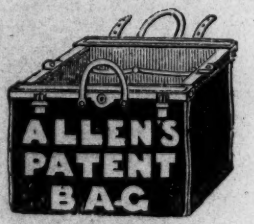

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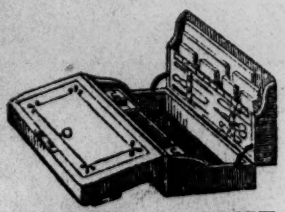

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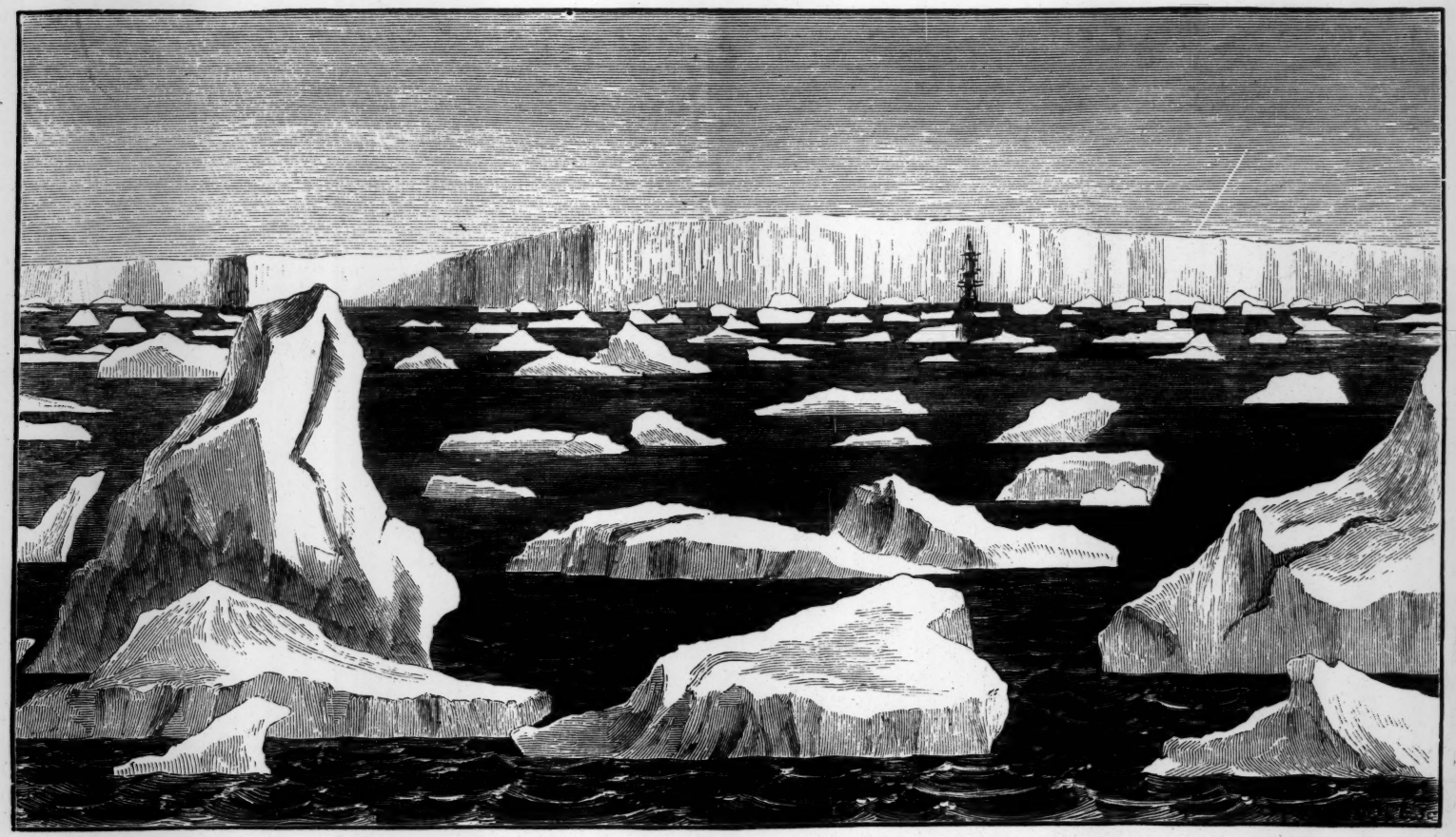


THE EDGE OF THE ANTARCTIC ICE-SHEET, WITH ICEBERGS, FROM A DRAWING BY SIR J. C. ROSS.

(From Geikie's 'Great Ice Age,' kindly lent by Messrs. Daldy, Isbister, & Co.)

EVIDENCES OF THE AGE OF ICE.

By HENRY WOODWARD, F.R.S., F.G.S., &c.

[PLATE III.]

ONLY a few years ago it was looked upon as an article of faith among geologists that the whole globe was once in a molten, incandescent state, and that the conditions of temperature now prevailing on the surface of the earth had been produced in process of time by the slow and gradual cooling of the once fused and glowing mass. But whatever may be the unknown heat of the deeper strata, that of the surface results solely from the great source of heat, the centre of attraction of our planetary system—the sun.

The oscillations between heat and cold that we experience from day to night, and from summer to winter, all depend on the laws of absorption and radiation of heat given off by the sun to the earth, or radiated by the earth into stellar space.

If the earth were a globe of perfect regularity, presenting on its surface no contrast of land and sea, plateaux and plains, snow and verdure, a nearly equable distribution of climates would be established over its whole extent, and one could exactly measure the degrees of heat by those of latitude.

But such we know is not the case. Every place has its own climate. Such variations depend on the elevation of the land above the sea; the position of a place, whether inland or on the coast; the direction and height of its mountain chains; the extent of its forests, savannahs, and cultivated lands; on the width of its valleys, the abundance of its rivers, the outline of its coast; on marine currents, prevalent winds, clouds, rain, fogs, &c.; these varied causes constitute, together with the latitude, what is called "the climate of a country." *

Undoubtedly the most important climatal phenomenon is that of temperature, for to heat we probably owe all the movements of the atmosphere which we call winds. Parts of the

* Elisée Reclus, "La Terre."

earth become overheated, and these put in motion the whole system of atmospheric currents; these too give to the winds the moisture destined to be dispersed as clouds, and to fall again on the earth as snow and rain.

The impulse to all these movements of air and water is given by the sun's rays; and on this luminous body all the life of our planet depends. To the facts, then, that the earth is so uneven in its surface configuration, that its land and water are so very irregularly distributed, and that it receives an unequal share of solar heat varying with the seasons and the latitudes, we owe that infinite variety of climate by which it is characterized.

One country near the polar circle receives more warmth than does another situated at a less distance from the tropics; one region of the temperate zone is hot in comparison with certain spaces in the equatorial zone. And in each place the temperature continually varies and oscillates under the action of winds, currents, and all the other agencies which affect climate; and when indicated by lines on the surface of the earth, an inextricable network is formed, of which we can only recognize the principal traits.

Fifty years ago Humboldt first conceived the idea of uniting by lines all those parts of the earth's surface having the same annual average temperature.

These imaginary lines traced on the circumference of the globe are called isothermal lines; they give the thermal latitude, which differs widely from the geometrical latitude.

While the lines of degrees traced every 69½ miles apart are parallel to the equator and perfectly regular, the isothermals are contorted into numerous and often sharp curves over all parts of the earth.

The thermal equator (or the curve of the greatest average heat, on each side of which the temperature gradually decreases towards the poles), lies almost entirely in the northern hemisphere, which is warmer than the southern.

The district of greatest heat lies between 10° and 60° E. longitude, and between 15° and 30° N. latitude; that is to say, it is the area to the east and west of the Red Sea, and embracing the greater part of that narrow gulf, and also that of Persia.

The district of greatest cold lies between 120° and 140° E. longitude, and between 60° and 80° N. latitude, along the course of the river Lena, the principal river of Siberia, covered during many months of the year by snow and ice; within the frozen mud and ice-cliffs at whose mouth have been found the entire carcasses of the mammoth and the woolly rhinoceros.

All these sinuosities of the isothermal lines over the earth's surface are caused by similar isolated areas of a higher or lower temperature, which deflect them in a greater or less degree from a straight course.

Thus in the southern hemisphere, where the continents are diminished gradually towards the south, and where the moderating influence of the ocean tends to eliminate all climatic differences, the lines of equal annual temperature seem to be pretty regular, and in the Antarctic Ocean they may be considered parallel to the degrees of latitude. The most marked curves of these southern isothermals are developed immediately to the west of Africa and the west of South America, where the influence of the currents of cold water flowing towards the equator from the Antarctic Ocean is most visibly demonstrable.

In the northern hemisphere the sinuosities of the isothermal lines are much more marked than in the southern, and cut the degrees of latitude at all angles. One of the highest of these isothermal waves is that which rises in latitude 45° N., off the coast of Halifax, Nova Scotia, passes to the south of Newfoundland, ascends in a north-easterly direction past the south-east coast of Iceland, attaining its summit about latitude 65° N.; it then bends down to Drontheim, Stockholm, and Moscow, falling again nearly to latitude 45° N. in Central Asia.

But whatever may be the sinuosities of the lines of equal temperature, they all indicate a more or less rapid decrease of heat between the equator and the two polar zones.

In the interior of continents, the chief modifications of climate are produced by mountain ranges and winds; on coasts and islands the climate depends on ocean currents and winds.

Happily for England, we enjoy here what is called an "insular climate." There are special reasons why the climate of the British Isles is so much milder than that of any other place in the same latitude, and we may with advantage consider these exceptional circumstances before proceeding further. Take, for example, two parallels of latitude at the present day. Off Little Belle Isle, in the month of July 1864, Mr. J. F. Campbell * records the temperature of the air at 48°, water 40° (wind south when the temperature was taken), and icebergs in sight. Mr. Campbell passed bergs 400 ft. deep and 200 ft. long, and many others of far larger size, some being 150 ft. above the water. Belle Isle is in the same latitude as London.

In 1831, Mr. Redfield states that the harbour of St. John's, Newfoundland, was completely blocked by ice so late as the month of June. This is 2° further south than the port of Liverpool, and yet one never heard of the port of Liverpool being blocked by ice, even in January! Again, the limit of constantly frozen ground which extends to the southern border of Hudson's Bay (where ice is found in digging wells in summer, at a depth of 4 ft. below the surface) is in the same latitude

* In his "Short American Tramp," p. 66.

as London. Nairn, on the desolate and frozen coast of Labrador, is in the same latitude as Dublin; yet the former has only a mean temperature of 28°, whilst Dublin has a mean temperature of 49°, or nearly double the warmth of Nairn. The cause of this great disparity in the relative temperature of places lying in the same parallels of latitude is to be found in the prevalence of certain winds and oceanic currents, which cause the isothermal line to bend northwards so many degrees in passing from west to east.

The ocean-current in which we are especially interested is that mighty stream which issues from the Gulf of Mexico, flows in a north-easterly course across the Atlantic, and is commonly known as the "Gulf-Stream."

Since 1842, when the energetic Captain Maury, of the United States Navy, first drew the attention of the American Government to the importance of preparing "wind and current charts," the Gulf-Stream has not wanted observers and historians. This remarkable oceanic current is about 25 miles in breadth off Cape Florida, and it increases to 127 miles off Sandy Hook, whilst its depth diminishes from 1,000 to 200 ft. and under as it proceeds northwards. From the American Coast and from the banks of Newfoundland it is deflected across the Atlantic, reaching the Azores in about 78 days, after flowing nearly 3,000 miles. Our own islands enjoy a portion of its warmth; and even Spitzbergen, in latitude 79° north, feels its influence, and before its warm breath the glaciers are stopped abruptly in their descent to the sea.

Mr. Croll has estimated the total quantity of water conveyed by the Gulf-Stream to be equal to that of a current of water 50 miles broad and 1,000 ft. in depth, flowing at the rate of 4 miles an hour, with a mean temperature of 65°. Before its return from its northern journey, he concludes it has cooled down at least 25°. Each cubic foot of water, therefore, has carried from the tropics upwards of 1,500 units of heat, or 1,158,000 foot-pounds.* Principal J. D. Forbes has calculated that the quantity of heat thrown into the Atlantic Ocean by the Gulf-Stream on a winter's day would be sufficient to raise the temperature of the air which rests on France and Great Britain from the freezing point to summer heat.

At the very time the Gulf-Stream is rushing in greatest volume through the Straits of Florida, and hastening to the north, a cold counter-current is descending from Baffin's Bay

* According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed every hour by the Gulf-Stream, or 133,816,320,000,000 cubic feet per day. The calculations of Sir John Herschel and Captain Maury make the amount still greater.

by Davis Straits to the south with almost equal velocity. This current flows inshore on the North American seaboard, and also beneath the Gulf-Stream, but does not mingle with its waters.

The Gulf-Stream is, of course, only one of many oceanic currents, but to us it has a pre-eminent degree of interest. It brings us genial showers, borne by the south-westerly winds, from the surface of its warm and steaming waters. It carries the temperature of summer even in the depths of winter as far north as the Great Banks of Newfoundland, and there maintains it in the midst of the severest frosts. It is the presence of this warm water and a cold atmosphere in juxtaposition which gives rise to the "silver-fogs" of Newfoundland, one of the most beautiful phenomena to be seen anywhere in the domains of the Frost King. Every west wind that blows crosses this stream on its way to Europe, and carries with it a portion of this heat to temper the inclemency of the northern winter. It is the influence of this stream upon the climate that makes Erin the "Emerald Isle," that clothes the shores of Albion in evergreen robes, and encourages the myrtle and magnolia to flourish at Mount Edgcombe in the open air all the year; it carries West Indian seeds to the Scottish isles, wafts the floating pteropod-shells to the latitude of Iceland, and renders the fauna of Spitzbergen richer than that of any other Arctic realm.

But all earthly advantages are transient, and not even the Gulf-Stream can be expected to be always so partial to us as it is to-day. Indeed, geologists are aware that formerly, owing to the subsidence of that narrow belt of land, the Isthmus of Panama, at one time, and probably by the subsidence of the Mississippi Valley at another, the Gulf-Stream has more than once been diverted from our coasts, and our islands were, as far as they were above water, glaciated even as the coasts of Labrador are at the present day.

Let us briefly consider the evidences on which geologists have relied in writing this latest chapter in the geological history of our island. These evidences are most abundant and varied; some of them, indeed, lie close to our own doors, and may easily be studied and examined. I allude to the great series of deposits known to geologists as "glacial deposits," and which have resulted either from the action of glaciers or icebergs, or some modification of them. These may be classified as follows:—

I.—1. Roches moutonnées.
2. Striated rock-surfaces.
3. Boulder-clay and 'till.'
4. Moraines of valley glaciers.

II.—5. Erratic blocks.
6. 'Kames,' 'eskers,' and sandy gravelly drift.
7. Stratified clays with arctic shells.

In some instances these can be divided into—

I. Those due to glaciers and coast-ice, whilst the land was greatly elevated (1 to 4).

II. Those due to the sea and icebergs whilst the land was greatly depressed (5, 6).

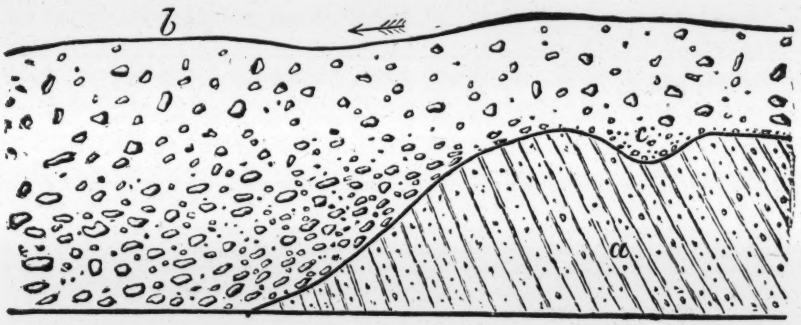
But many of them are so altered and reconstructed that it is exceedingly difficult to attribute them to one or other of these divisions. What evidences, then, have we to-day?

"The general surface of a great part of the British Islands," says Mr. James Geikie, "excluding the centre and south of England, has a smoothed contour, which is now generally recognized as the work of land-ice.

"Hills, valleys, and knolls of rock have been ground down and have received that characteristic flowing outline which ice alone, of all natural agencies, can produce (*roches moutonnées*). When, moreover, we strip off the superficial cover of detritus and examine the surface of rock underneath, we find it covered with the well-known grooving and striation such as are met with by the side of every modern glacier in the Alps.

"These markings are not disposed at random, but run in more or less parallel lines. And when we examine them over the

FIG. 1.



SECTION AT EAST END OF NEIDPATH TUNNEL, PEEBLES.

a, Silurian rocks; *b*, till, showing arrangement of stones on the lee side of the rock; *c*, gravel in a hollow under the till. The arrow indicates the direction in which the till has travelled.

length and breadth of the country, we discover that they point away outwards in every direction from the main masses of high ground, indicating that the ice which produced them covered the land in a deep continuous sheet, like that of Greenland, and that it moved outward and downward from the high grounds to the sea. So vast was the mass of ice that it swept over considerable hills, smoothing and striating their sides and summits."*

To this period Professor Ramsay refers the general erosion of the present lake-basins of Britain.

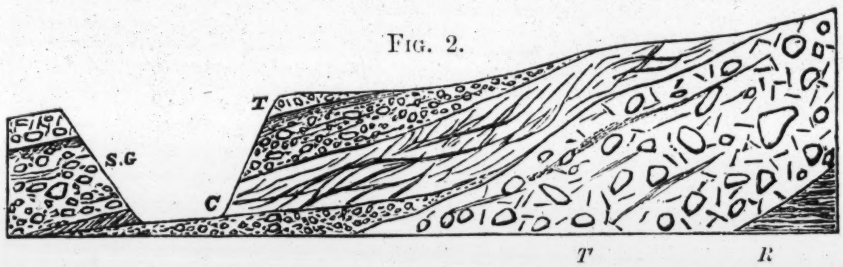
* Geikie, "Great Ice Age."

Another feature of the surface-geology of the country dates from the same period—the widely-distributed boulder-clay, or "till." This deposit is not at all likely to be confounded with any other. It consists of a mass of unstratified clay, with blocks and boulders of stone stuck into it promiscuously, the whole seeming to be the result of an irregular "pell-mell" carrying forward and deposition of the materials (see figs. 1 and 2).

The colour and general composition of the mass may vary according to the nature of the rocks from which it has been derived. Thus, in a region of dark Carboniferous shales the boulder clay is leaden, grey, or black; in one of Old Red, or Triassic sandstones, it is red. In the Chalk country it is quite full of bits of chalk, and is hence called the "chalky boulder clay."

The stones in the clay range in size from mere grains of sand up to masses a yard or more in length. Wherever the rock of

FIG. 2.



SECTION OF GLACIAL DEPOSITS IN THE SETTLE AND CARLISLE RAILWAY CUTTING AT CULGAITH.*

T, upper till; *S G*, sand and gravel; *C*, laminated clay; *T'*, lower till; *R*, rock
Length, 40 feet.

which they consist has been of a kind to receive and retain surface markings, the stones are found to be covered with ruts and striæ, which run for the most part in the direction of the long axis of each stone.

There can hardly be any doubt that these markings have been produced under a sheet of land-ice similar to that which covers the whole interior of Greenland at the present day.

This great inland ice-sheet, that at places advances to the coast and thrusts the snouts of its glaciers into the sea itself, giving rise to enormous icebergs, covers the entire continent of Greenland save a few dozen miles at most of coastline, which remain free. It forms on its seaward face precipitous cliffs of ice about 200 feet high, covered with a thin layer of earth and stones, but rises at first rapidly, afterwards more slowly, to a height of several thousand feet. During Professor Nordenskiöld's expedition to Greenland in 1870, he made an excursion upon this inland ice-sheet with one companion, Dr. Berggen,

* We are indebted for the loan of this block to the Council of the Geological Society.

and two Greenlanders.* They penetrated thirty miles into the interior in four days, attaining an altitude of 2,200 feet above the level of the sea.

No moraine-matter was observed on the surface of the ice; but everywhere, under the influence of the sun's rays, this immense ice-field was in motion internally, and large rivers and lakes on its surface descended through the ice in roaring torrents, by "swallow-holes" 2,000 feet deep, to join the streams which flowed beneath.

The ice-sheet which some geologists believe to have been once co-extensive with our island, covering it from its sea-level to the highest peak of its loftiest mountains in Wales or Scotland, was, it is assumed, only a repetition of the present state of Greenland, or, on a larger scale, of what one may see taking place to-day on the Alps and the Himalayas and other mountain ranges, whose heads are covered by perennial snows. For the process of reduction of temperature takes place in a corresponding ratio, whether we sail to the North Pole with the *Alert* and *Discovery*, or with Professor Tyndall scale the heights of the Matterhorn or Monte Rosa.

If, then, temperature decreases with altitude above the sea-level, an elevation of our island would produce the same effect upon it as if we could transport it bodily to the latitude of Greenland!

It is well to keep these facts clearly before the mind, because, among the numerous explanations offered by our leading geologists, this question of the *relative elevation* above the sea-level has not had that prominence given to it in the discussion which it deserves. The results of *altitude* have in fact been confounded with those of *latitude*.

The stones that occur in the boulder-clay spread over so many counties in England differ widely in character; and, from a study of these, it is possible to determine the direction in which the ice-sheet moved, and the centres of dispersion whence the boulders were derived.

Wherever the surface of the rock is of sufficient hardness it is everywhere polished, rounded, and striated in a precisely similar manner to what is seen to be taking place in valleys occupied by glaciers at the present day; whilst the boulder-clay is the finely comminuted particles worn down to powder, like the grains of wheat into flour, by the glacial millstone, and poured out in a turbid stream, or pushed along as a great rampart of stones and rubbish forming the terminal moraine, as we see it at the foot of the Mer de Glace, above Chamounix, or, at times,

* The Greenlanders turned back after two days, but Nordenskiöld and his companion pushed on two days' journey further.

as in Greenland, pushed into the sea itself, for in Lancashire this deposit is associated with fragments of marine shells.

Where this is the case, the finer particles have been carried away and re-assorted by sea-currents and mixed with marine organisms, as in the Clyde glacial beds; the shells indicating arctic conditions.

During one period of the glacial epoch we had a great depression of the land; to such an extent, indeed, that these glacial deposits, associated with marine shells identical with species now existing, have been found in Cheshire up to a height of 1,200 feet. On Moel Tryfaen, near the Menai Straits, fifty-seven species of shells of marine mollusca have been obtained (all indicative of a colder climate than that of our present sea) at a height of 1,300 feet above the sea.

It was at this period, no doubt, that icebergs and floes of ice laden with boulders and other foreign material were transported from the western and northern highlands and dropped their burdens, on melting, over and about where London now stands, especially in the neighbourhood of Finchley and Muswell Hill, where vast numbers of erratic blocks have been observed, and numbers of transported fossils have been collected by the late Mr. N. T. Wetherell, F.G.S., and other geologists.

Various theories have been brought forward in explanation of the glacial epoch. Among these that of Mr. James Croll, F.R.S., of the Scottish Branch of the Geological Survey (also adopted in the main by Mr. James Geikie, F.R.S.), has been largely advocated. It is based on the calculation that at certain unequal periods, owing to the eccentricity of our earth's orbit around the sun, the earth is occasionally somewhat further distant from the sun than at the present time (98,500,000 miles, instead of as at present, 90,500,000; or, to be exact, 8,641,876 miles more distant). The last occasion Mr. Croll puts at 200,000 years ago.

The other cosmical cause advocated by Mr. Croll is the slight variation in the polar obliquity of our earth, which varies through long periods between $23\frac{1}{2}°$ and $24\frac{1}{2}°$.

When the earth, from these two causes combined, became subject to a slight variation in its two hemispheres, which would give to one $7\frac{1}{2}$ days more of the sun's presence in one tropic than the other now enjoys, then Mr. Croll concludes the ice on the more favoured pole would melt, and that on the less favoured would increase; and this cause alternating, would give rise at long intervals to alternate glacial epochs in each hemisphere, accompanied by displacements of the earth's centre of gravity, and a rising of the waters of the sea combined with an increase of ice at the pole.*

* See Mr. Croll's paper on the Glacial Epoch, "Geol. Mag.," 1874, p. 348.

Mr. James Geikie, in his book on "The Great Ice Age," actually makes two glacial epochs with an interglacial period between them, into which period he introduces—1st, a milder cold temperate climate, with the mammoth, the woolly-coated rhinoceros for denizens of our forests, and the great bear dwelling in our caves, the winters still severe. 2nd, a warmer subtropical climate, with the retreat of the arctic mammalia northwards, and the advance from the south of the hippopotamus, the cave-lion, the hyæna, and palæolithic man, evidenced by the rude flint implements found in valley gravels.

Then followed another cold period, before which the southern mammalia disappeared, and were again succeeded by arctic animals. Even these, however, migrated southward, leaving the land to be again overspread with ice and snow.

Mr. Geikie admits that there were not unfrequent shiftings in the distribution of land and sea, but these do not seem to him to have been the chief causes of these climatal changes. After this second cold period, Mr. Geikie next introduces the submergence of the British Islands to 2,000 feet; gives it a final refrigeration, in which period the drifts and angular erratic blocks were scattered over the South of England, and over North Germany and Russia, and the Swiss glaciers were augmented. Then Britain for the last time—

Arose from out the azure main,

to be again re-forested and re-peopled, this time by the moose-deer and the cariboo or reindeer, the arctic fox, the lemming, and the marmot; and Neolithic man became the denizen of our caves and woods, and made pictures of the animals he there saw and hunted.

The only considerable change which Mr. Geikie proposes to introduce at this period is the severance of our island from the continent, and the complete insulation of Britain.

I hope it may be possible to simplify this chapter of our Glacial epoch, and here I am glad to say I have the high authority of Professor Nordenskiöld, who has visited both Spitzbergen and Greenland more than once, that from the evidence of fossils obtained in a succession of beds in arctic latitudes, he is led to the conclusion that there has not been in past geological times a periodical alternation of warm and cold climates on the surface of the earth.

In Eocene Tertiary times sub-tropical conditions prevailed in the latitudes of London and Paris, and both plants and animals betokened a temperature at least as high as that of North Africa.

Since that period, through Miocene and Pliocene formations, we are able to trace a gradual lowering of the temperature of

our islands by the more temperate sub-arctic and arctic character of their faunas, and what traces remain of their floras also.

Then came the Glacial period, first initiated perhaps by the diversion of the Gulf-Stream, caused by the subsidence of the Isthmus of Panama, or more probably by the opening up of a course for its waters up the great central valley of North America, down which the Mississippi river now flows, and which, save a narrow strip between Lake Superior and Hudson's Bay, is nowhere more than 800 feet above the level of the sea; this, if lowered, would give a direct course for the Gulf-Stream up to the north-west coast of Greenland and to Smith's Sound.

Afterwards, by the elevation of the land only 600 feet, this island would be united to the continent on the one hand, and to Ireland on the other; whilst its shores would extend outwards to the margin of the plateau of Ireland, seventy miles to the west, and from beyond the Shetlands in the north to near the north-west of Spain in the south.

Probably the elevation was far greater, for the British Isles have a powerful line of volcanic disturbance running down about the meridian of 6° west longitude, which in the western Highlands and the north of Ireland was active down to an exceedingly late geological period (Miocene).

If it be necessary to call in extra-mundane causes to explain the great increase of ice at this glacial period, I would prefer the theory propounded by Dr. Robert Hooke, in 1688; since by Sir Richard Phillips and others; and lastly by Mr. Thomas Belt, C.E., F.G.S.; namely, a slight increase in the present obliquity of the ecliptic—a proposal in perfect accord with other known astronomical facts, and the introduction of which involves no disturbance of that harmony which is essential to our cosmical condition as a unit in the great solar system.*

Such an increase in the obliquity of our earth's axis would result in an increase of ice, not at one pole at a time, as proposed by Mr Croll, but at both poles simultaneously; a condition which accords with the fact that with our present obliquity we have ice at both poles now; the larger supply at the antarctic being purely caused by the fact that in the southern hemisphere we have a polar continent surrounded by a circumpolar ocean (fig. 4), whereas in the arctic we have a polar sea surrounded by circumpolar land (fig. 3).

* In Jupiter the axis is nearly perpendicular to the plane of its orbit. In Saturn the obliquity is 29°. In Mars it is $30\frac{1}{4}°$; in Venus it reaches the extreme of 75°, so that its tropics actually overlap its arctic circle, and there are no temperate zones. The earth has an inclination of $23\frac{1}{2}°$. It is estimated that its axis may have been inclined as much as $35\frac{1}{2}°$ during the glacial period.

The ocean is the great evaporating dish, the continent the condenser; hence the larger glaciers of the southern pole, where the ice-wall of the land ice, which in Greenland stops some miles inland, here comes down into the sea itself (Pl. III.), ploughing up the sea bed, and spreading out its terminal moraine in the ocean.

What length of time has elapsed since the Glacial epoch occurred we cannot pretend to say; Mr. Belt estimates the date to have been 20,000 years since, Mr. Croll 200,000 years ago. We may therefore, I think, rest content with the geological evidences of a modification of the climate afforded by the re-

FIG. 3.

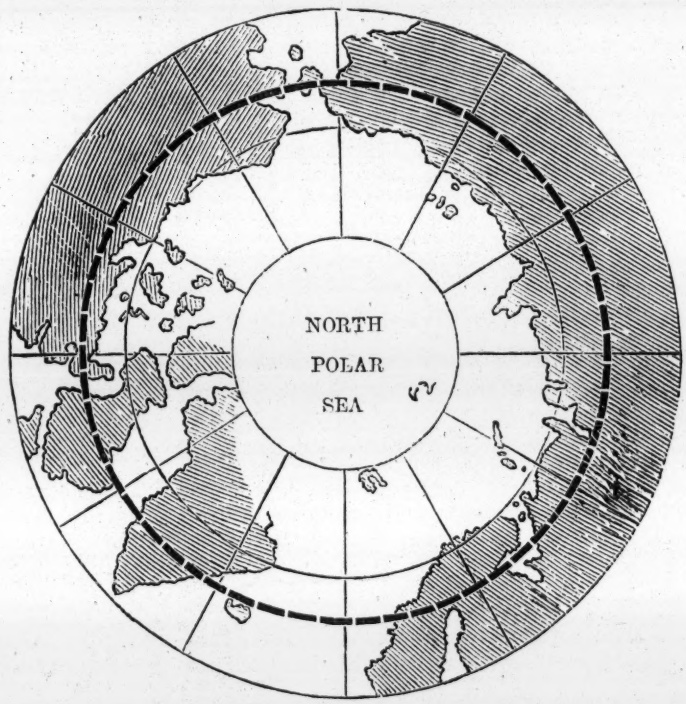


DIAGRAM OF NORTH POLAR SEA.

A marine area almost surrounded by land. To contrast with Fig. 4, the South Pole having a land surface entirely surrounded by ocean.

mains of glaciers and icebergs and the zoological evidence of a former change in the distribution of the mammalia telling the same story.

I believe the musk-sheep and the mammoth were both præ- and post-glacial animals, and that the mammoth survived till after the climate became milder, but that he was a scarce animal from that time. The musk-sheep lives on still in Arctic North America.* The sabre-toothed lion (*Machairodus*) is so rare

* See the beautiful specimen lately presented to the British Museum by Capt. Feilden, the naturalist on board H.M.S. *Discovery*, and now on exhibition in the Zoolo gical Gallery.

with us, as a fossil, that we may fairly assume he belonged to the earlier præglacial cave period, as did the panther, lion, lynx, hippopotamus, two species of rhinoceros, and one variety of mammoth (*Elephas antiquus*).

If the Esquimaux of Greenland live on the borders of the ice-fields, and many animals flourish there also, and birds are most abundant, it is fair to assume that, on the retreat of the ice, man and animals advanced and occupied all the fertile valleys and pursued the chase as the Lapps, Finns, Tungusians, Samoiedes,

FIG. 4.

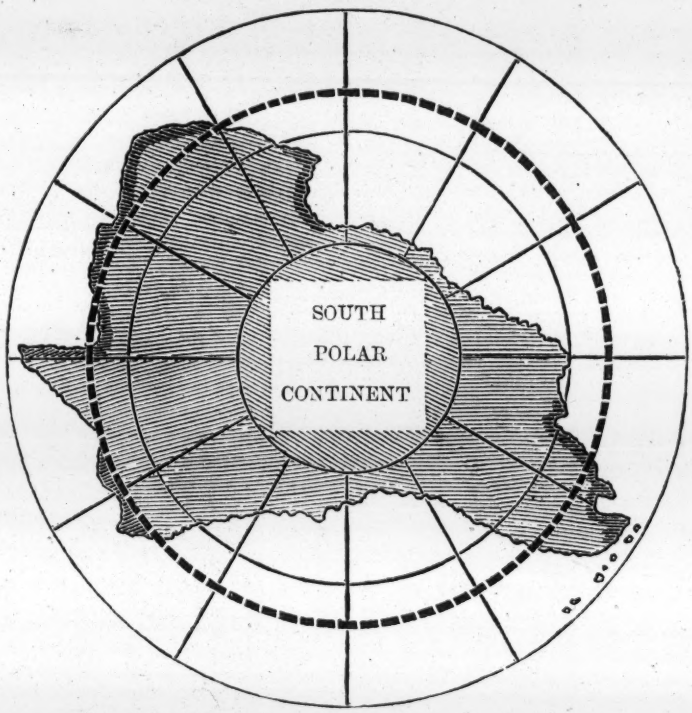


DIAGRAM OF THE SOUTH POLAR CONTINENT.

To illustrate the vast land area forming the gathering ground for the great Antarctic icebergs. The darker parts along the margins of the South Polar land indicate those portions which have been actually coasted along, such as South Victoria Land (with Mounts "Erebus" and "Terror"), Enderby Land, Trinity Land, &c.

American Indians, and Esquimaux have done in our times further north.

We speak of the stable land; but we must always remember that, whether the land is upheaved by volcanic energy from beneath, or the sea-level lowered by the abstraction of water and the piling up of snow and ice on the circumpolar lands, the effect is the same to man as an observer. This however we know, that in the latest geological period—the Tertiary (both Miocene and Pliocene) early man may have been a witness of some of the

largest exhibitions of elevatory force on our earth's surface ; for in these later periods the great Himalayan, Persian, Carpathian, and Alpine chains have been upraised, carrying high upon their flanks, as a part of their structure, beds of Nummulitic limestone of Middle Eocene age!

If, then, the Himalayas with Mount Everest have been raised up to 29,000 feet above the sea in this recent period, our islands may well have oscillated a few hundreds of feet ; and trivial as such phenomena may be when compared to the elevation of the great backbone of the Asiatic Continent, nevertheless these lesser changes have for us an interest which even the lofty mountain masses do not possess. Nor is it an idle question to ask—"Was man present to witness these modifications of our islands?" He may have been, judging by his implements. Certainly in France and Switzerland he saw and killed the musk-sheep; and in France he also saw the mammoth alive and pictured him. But the reindeer and the horse were the chief objects of the chase, as their remains testify. Nor is it at all improbable that these nomadic cave-dwellers are represented to-day by the tribes of the Arctic seaboard, who have retreated with the amelioration of the climate which compelled the reindeer to go further north to give place to more southern animals and hunters, and these in time to civilized man himself.

MINERAL CAVITIES AND THEIR CONTENTS.

By W. N. HARTLEY, F.R.S.E.,

KING'S COLLEGE, LONDON.

"THERE are few enquiries in natural science more calculated to awaken curiosity than those relating to the changes which the matter composing the surface of the globe has undergone. The imagination is excited by the magnitude of the operations, by the obscurity of the phenomena, and the remoteness of the time at which they occurred; and all the intellectual powers are required to be brought into activity to find facts or analogies, or to institute experiments by which they may be referred to 'known causes.'"

The foregoing passage was written by Sir Humphry Davy, when President of the Royal Society, in the year 1822, and it was certainly never more full of truth than at the present day, notwithstanding the advances in physics, chemistry, and geology which have since been made.

It formed the preface to a paper on the aqueous and gaseous contents of the fluid-cavities of minerals. These cavities, which are most commonly found of large size in rock crystal, were relieved of their contents by boring holes in them with a diamond, the specimens being submerged in mercury or in water. Wires were inserted to displace the gases, and capillary tubes to draw off the liquid, much in the same way that vaccine matter is drawn off from a vesicle. The liquid was found to be in almost every case either pure water or some dilute saline solution containing a sulphate or a chloride of sodium or potassium. The gaseous portion was nitrogen, generally in a rarefied condition, but having in one case a tension equal to ten times that of the atmosphere. It was undoubtedly proved that the brown viscid liquid in one crystal was mineral naphtha.

Sir David Brewster, in the following year, announced the discovery of a remarkable liquid—or, as he then said, two liquids

—in the cavities of topazes, in rock crystal, and in chryso-beryls. He was led to the investigation by reason of the violent explosion of a topaz which he was heating in order to observe its change of colour. He also became acquainted with the fact that a Mr. Sanderson, a jeweller in Edinburgh, placed a topaz in his mouth, upon which it exploded with great violence, the fragments inflicting a wound. Under the title of "Explosive Gems," a note occurs in Brewster's "Natural Magic" giving an account of his researches.

In the year 1860 Mr. Alexander Bryson, of Edinburgh, having made a microscopic examination of rock sections during the previous ten years, published a note on the formation of granite. Fluid-cavities were noticed in many specimens, the gas-bubbles in which disappeared when warmed on a hot stage to 35° C. (97° F.), and returned on cooling to 29° (84°·2 F.), the liquid undergoing at the same time a sort of boiling movement. This apparent ebullition had previously been noticed likewise by Brewster. Not knowing the nature of the liquid, Bryson concluded that granite was crystallised from aqueous solutions at a temperature not exceeding 29° C. (84°·2 F.) He remarked the same liquid in hexagonal prisms of quartz, in porphyry from Dun Dhu in the Isle of Arran, in the schorl of Aberdeen granite, and also in the trap tufa of the Calton Hill, the basalt of Samson's Ribs, and in greenstone from the Crags in the Queen's Park, Edinburgh.

There is a particular line of research which bears on these liquids. First of all the experiments of the Count Cagniard de la Tour, who, in the year 1822, showed the possibility of converting a liquid into vapour, in spite of any high pressure it may be subjected to, if only the temperature be sufficiently high. The most successful experiments in sealed glass tubes were made with ether, and, when the liquid occupied even as much as half the capacity of the tube, it ceased to be a liquid at a temperature of 150° C. (302° F.) Experiments with water similarly conducted always resulted in a disruption of the tube, most probably because of the solvent action of water upon the glass at high temperatures. In order to overcome this difficulty Cagniard de la Tour made use of a gun-barrel, closed completely by an accurately fitting screw plug. At the upper part of the tube was placed a marble, and when the lower end, containing water, had been heated to about the temperature of melted zinc, it was found that the marble on shaking rattled when it fell against the lower end. There was nothing within to "break its fall," as there otherwise would have been if the tube had contained a liquid. When the tube had cooled the conditions were altered, and the water itself could be heard. This remarkably ingenious and striking experiment proved the possibility of converting even water entirely into vapour despite

an enormous pressure. The reasoning is of course applicable to all liquids. The presence of air was no obstacle to such change; it only rendered the dilatation of the liquid more regular, and the more easily observed in glass tubes up to the moment when it vanished completely.

Although Guyton de Morveau, towards the end of the last century, had liquefied ammonia gas by exposure to a temperature of −48° C. (−54°·4 F.), and Monge and Clonet had liquefied sulphurous acid, yet their results appeared so incredible that doubt was cast upon them, on the supposition that the gases were not sufficiently dry. Northmore, in 1805–6, liquefied hydrochloric acid, sulphurous acid, and chlorine by pressure, but in such a manner that they were not obtained in a pure state. It is, therefore, to Faraday that we owe our first and most trustworthy information on the liquefaction of gases. His first paper appeared in 1823, and the second more complete publication in 1844. In this latter, when describing the properties of liquid carbonic acid, he says: "I am inclined to think that at about 90° F. Cagniard de la Tour's state comes on." In other words, he believed that at the temperature of 90° F. (32°·2 C.) the carbonic acid enclosed in sealed tubes ceased to be a liquid, and was resolved into a vapour.

Mr. George Gore, of Birmingham, has examined the solvent powers of many liquefied gases, and these are not at all such as one would expect. Thus the immiscibility of carbonic acid with water, and its power of dissolving iodine with a violet colour like that of the solution made with bisulphide of carbon, have been shown. Liquefied hydrochloric acid loses the chemical activity its aqueous solution possesses; for instance, it does not redden litmus paper, and it is quite inert in contact with a powerful base like caustic lime.

The next point is the knowledge which Thilorier gave us concerning the properties of the liquid carbonic acid. He prepared it in large quantities and daringly sealed it up in glass tubes in a state of perfect purity; in this way he was enabled to ascertain its tension at different temperatures, and its rate of expansion.

Now Simmler in 1858, offering an interpretation of Brewster's observations, pointed out that the new liquid, in some cases at least, was most probably liquefied carbonic acid. The most remarkable physical property of this liquid of Brewster's was its enormous expansibility by heat, and on comparing Thilorier's co-efficient of expansion for this liquid with that which Brewster estimated for the expansion of the liquid in crystals, he found them to be almost identical. This comparison was accomplished, however, in a much more satisfactory manner, in 1869, by Messrs. Sorby and Butler, who published conjointly an

account of their researches on the structure of rubies, sapphires, diamonds, and other minerals. The rate of expansion of the liquid contents of an unusually large cavity in a sapphire between the temperatures of 0° and 30° C. (or 32° and 86° F.) was measured and compared with that of liquid carbonic acid as determined by Thilorier, between these two temperatures. It was found to agree so closely with the surprising dilatability of carbonic acid, that they had no hesitation in concluding that any difference might be due to an error in one of the thermometers.

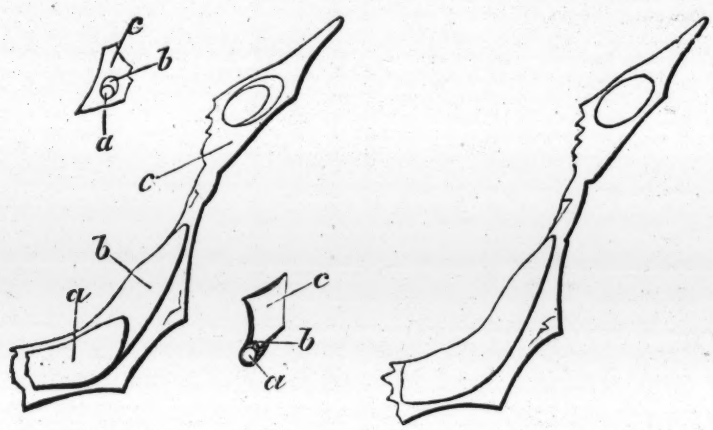
Mr. Sorby found that 100 volumes of the liquid in the sapphire expanded to 150 volumes at 30° C. (86°·F.), to 174 volumes at 31° C. (87°·8 F.), and to 217 volumes at 32° C. (89°·6 F.), something quite unapproachable by any other substance, even a gas.

In the same year, 1869, Vogelsang and Geissler, of Bonn, published an account of experiments made on rock crystal, in which the former observer had noticed a liquid floating upon water enclosed in cavities. They crushed the quartz under baryta-water and found that the latter became turbid, owing to the formation of carbonate of baryta, and they measured the rate of expansion of the liquid as nearly as the shape of the cavities admitted of this being done. Their most remarkable experiments, however, were performed in the following manner:—Taking a small retort containing a mineral in fragments, it was attached to a tube commonly known as a Geissler vacuum-tube. There were platinum wires sealed in at each end of the tube, and to one end was affixed an ordinary Sprengel pump. After a vacuum had been produced so that an electric spark would no longer pass across from wire to wire, the fragments of the mineral were heated, the mineral decrepitated, because the cavities exploded, and the spark passed through, because the previously vacuous space then contained a gas. This gas, when examined by the spectroscope, declared itself to be carbonic acid.

To Professor Andrews, of Belfast, we are indebted for extraordinary additions to our knowledge of the gaseous and liquid states of matter. He has established the fact that there is no gap between these two conditions; a liquid may pass by a gradual change of properties into a gas. It expands and becomes excessively mobile; the boundary between gas and liquid is less and less easily recognized, until it finally disappears. When the reverse change occurs, the gas becomes more and more compressible, a wavering and flickering movement is visible, a line of demarcation appears, and this, as the liquid contracts, becomes more and more distinct. These changes were observed in very strong glass tubes of small bore, which being filled with carbonic

acid, were screwed on to a reservoir of mercury. Compression of the gas within the tubes was accomplished by the action of a screw upon the mercury; the joints of the apparatus, being rendered tight by greased leather washers and cobbler's wax, were capable of sustaining a pressure equal to 500 atmospheres for days together. At no temperature above 30°·92 C. (87°·6 F.) was it found possible to maintain the liquid condition of carbonic acid, no matter what the pressure might be. This temperature is called by Professor Andrews the "Critical Point" of carbonic acid, and the condition of the substance is that mentioned by Faraday as "Cagniard de la Tour's state." Each gas and liquid has a fixed and definite temperature for its Critical Point, and this, in such gases as hydrogen, nitrogen, and oxygen, is below the reach of

FIG. 1, FIG. 2.



A CAVITY IN ROCK CRYSTAL CONTAINING CARBONIC ACID[1]
× 46 *diameters.*

Fig. 1.—*a* is gaseous carbonic acid; *b* is liquid carbonic acid; *c* is water. These letters also apply to the smaller cavities.

Fig. 2.—The specimen warmed to 31° C.; the line of demarcation between gas and liquid has disappeared. The water is seen undisturbed.

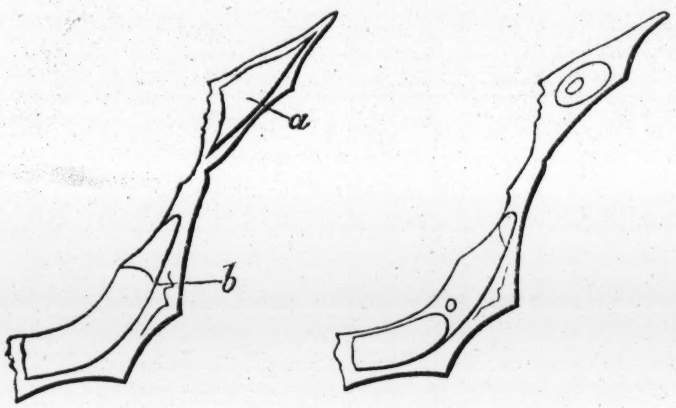
any refrigerative apparatus at present known to us; hence any pressure we may put upon them will fail to cause liquefaction.

Professor Andrews last summer lectured to the Fellows of the Chemical Society on the methods of research which are peculiarly his own. He completely charmed his audience by his easy conversational manner and by the way he took one into his confidence, explaining all his difficulties and how he overcame them. Anything of the kind more delightful has seldom been heard. Every one shared his enthusiasm.

[1] Figs. 1, 2, 3, 4, 8, 9 and 10 are reproduced from the "Journal of the Chemical Society," by permission of the Council.

In 1872 the writer bought a section of rock crystal containing fluid-cavities, with the object of submitting these to Cagniard de la Tour's experiment and watching the effect under the microscope, as it was thought that rock crystal would be proof against the corroding action of water. On warming the specimen gently over a lamp, it was found that a cavity previously seen to contain a liquid was apparently empty. Carefully watching the cavity under the microscope, the replacement of the liquid was noticed. Bearing in mind the experience of Professor Andrews, it seemed desirable to know at what temperature the liquid disappeared, for it was most probable that it had attained its critical point. The simplest mode of operating appeared to consist in immersing the

FIG. 3. FIG. 4.



A CAVITY IN ROCK CRYSTAL CONTAINING CARBONIC ACID
× 46 *diameters.*

Fig. 3.—*a* shows the shape of the cavity at its upper end when the water s driven out into the lower part. At *b* is seen the faint line indicating the surface of the liquid carbonic acid, as seen when warm. It should be compared with Fig. 1.

Fig. 4 simply shows how the liquid can be driven from the lower to the upper end of the cavity, or *vice versâ*, by a heated wire.

These drawings are from the microscope, and therefore must be inverted to get their true position.

slide in water of known temperature, removing, wiping it hastily, placing it on the microscope stage, and instantly examining it. A number of experiments showed that the liquid disappeared at 30°·8 C. to 30°·9 C., and returned instantly at any lower temperature. Here was most convincing evidence that the liquid was carbonic acid. The adjoining woodcuts (figs. 1–4) will convey to the eye of the reader the general aspect of this cavity.

The fact mainly regarded of interest in connection with this specimen was that the liquid never expanded by heat; thus

it differs from that in cavities examined by any previous observer.

The following observation of Thilorier explains the reason:—"When a tube containing liquid carbonic acid is one-third full, at 0° C., it constitutes a *retrograde thermometer*, in which increase of temperature is shown by diminished volume, consequent on the vaporization of the liquid, and *vice versâ*; while if the tube be two-thirds full, a *normal thermometer* of great sensitiveness is the result, the liquid expanding by heat in this case" ("Ann. Chim. Phys." [2], lx. 249).

FIG. 5.

CAVITY IN TOPAZ at 18° C. × 70 *diam*

Heat expands the liquid. A, gaseous carbonic acid. B, liquid carbonic acid.

It will be seen that in the cavity the proportion of liquid to gas resembles that in a retrograde thermometer, and furthermore the approach of a warm wire causes the liquid gradually to diminish. Especially rapid is this action as the critical point is approached, and at the same time the line of demarcation between liquid and gas gets fainter, and it loses its curvature. (See fig. 3.)

There was also noticed a faint flickering shadow in the point of the cavity when the liquid was about to condense. This is doubtless an effect corresponding to the striæ noticed by Professor Andrews. The liquid carbonic acid was always found floating on water if this latter substance happened to

FIG. 6.

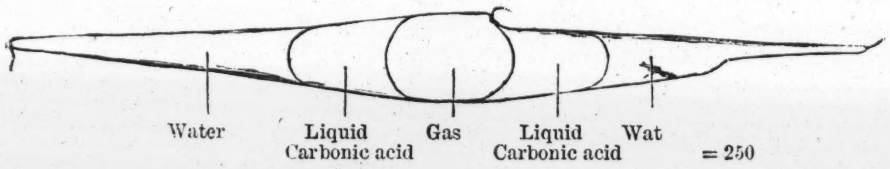
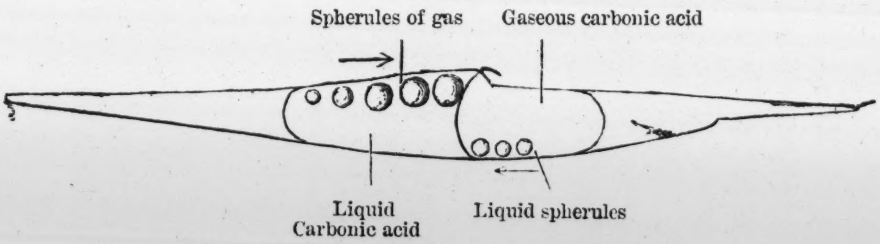


FIG. 7.

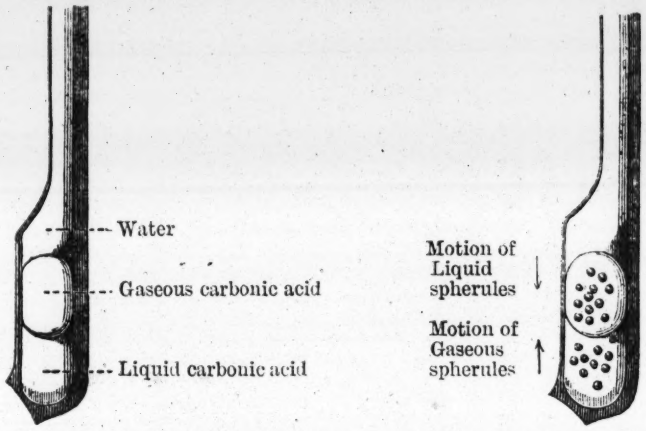


LIQUID CAVITY IN TOURMALINE × 250 *diameters.*

be present, and this is quite in accordance with the specific gravity as estimated by Thilorier, which at 0° C. is 0·83 and at 30° C. is 0·6.

A cavity of quite a different description is that found in a topaz (fig. 5). It contains only a trace of water, and is at ordinary temperatures filled to the extent of two-thirds its capacity by liquid carbonic acid. Rise of temperature expands this liquid until it entirely fills up the space occupied by gas, after which expansion the critical point is very easily

FIG. 8. FIG. 9.

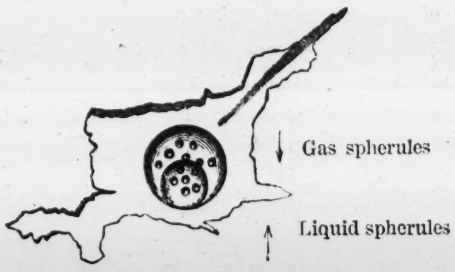


A CAVITY IN A TOPAZ.

Fig. 8 shows the proportions of liquid and gaseous carbonic acid and water. Fig. 9 shows the boiling motion when it has nearly terminated.

attained. A very curious appearance, resembling ebullition, follows as the gas returns to liquid, the explanation of which is as follows :—When the gas is chilled, a sort of mist forms throughout the space ; the individual spherules of this mist grow so large that they begin to touch each other, to coalesce, and to gravitate. They of course at the same time entangle gas, and as

FIG. 10.



A CAVITY IN ROCK CRYSTAL.

they descend to the lower part of the cavity the spherules of gas (bubbles) take an opposite direction ; consequently when a portion of the liquid has collected at the lower end and gas at the upper, there are showers of liquid descending into, and streams of bubbles rising out of the liquid. In two or three

seconds the movements have ceased. This ebullition is illustrated by a drawing of a cavity in another topaz, which contains at ordinary temperatures about equal volumes of water, gaseous carbonic acid, and liquid carbonic acid (figs. 8 and 9). A similar cavity as to its contents, but being exceedingly shallow, and having the bubbles within it much flattened, is that existing in a tourmaline (figs. 6 and 7). The drawing, fig. 10, represents a cavity seen in a specimen of quartz; the contents are undergoing apparent boiling. The conditions favouring this singular mode of condensation seem to be, first, that the greater part of the carbonic acid shall be in the liquefied state at ordinary temperatures, so that the liquid expands greatly on approaching the critical point; secondly, that the cooling shall be sudden. This seeming ebullition is the only test which as a general rule is significant of the liquid having passed its critical point, for we cannot tell after the substance has expanded so as to entirely fill the cavity, whether it be in the gaseous or the liquid state.

The following table shows several variations noticed in the critical point of carbonic acid existing in various minerals:—

	Critical point.
Topaz	28° C. = 82°·4 F.
Topaz	28° and 26°·5 C. = 82°·4 F. and 79°·7 F.
Topaz	27°·55 C. = 81°·5 F.
Tourmaline	27°·27 C.
Tourmaline	26°·9 C.
Sapphire	between 30°·5 and 31° C.
Sapphire	between 25°·5 and 26° C.
Sapphire	29°·5 C. = 85°·1 F.
Rock crystal	30°·95 C. } = 87°·71 F.
Rock crystal	30°·95 C. }
Rock crystal	32°·5 C. = 90°·5 F.
Rock crystal	33°·7 C.
Rock crystal	29° C. = 84°·2 F.
Rock crystal	30°·95 C.
Beryl	30°·92 C. = 87°·6 F.
Rock crystal	21° C. = 69°·8 F.

It is noticeable that in the sapphires, topazes, and tourmalines the critical point is lowered a few degrees, while in one specimen of rock crystal the temperature is nearly 10° C. or 18° F. below what it should be. Fortunately, Professor Andrews has shown that the critical point undergoes such a change when traces of any incondensable gas are present. Carbonic acid containing 15 per cent. by volume of nitrogen has a critical point of about 21° C., and it is not at all unlikely that this is the gas here present, since Sir Humphry Davy detected it in the fluid-cavities

of quartz, and it frequently escapes in a pure state from mineral springs and fissures in the earth's crust.

A great number of rock sections, chiefly porphyries, granites, and basalts, have been examined for liquid carbonic acid, in but few cases, however, with success.

In making these observations it is necessary to get rid of the influence of the mineral causing double refraction, by fixing a Nicol's prism on to the microscope stage; otherwise in small water cavities the appearances are very similar to those seen when two liquids are present, so that one may be easily deceived.

An exceedingly useful little contrivance for applying heat to the specimens of crystals containing fluid-cavities, consists of a glass tube about $\frac{3}{8}$ of an inch in diameter and 12 inches long; it is drawn out at one end to a jet of about $\frac{1}{16}$ of an inch aperture, the jet being bent at an obtuse angle at about an inch from the point. To prevent the glass being softened and bending when heated, it is covered for four inches in its central part by a piece of brass tube, which just slides on not too easily. The straight end of the tube is somewhat pointed, and passes through an india-rubber cork fitting into a universal joint upon a stand having a sliding motion in the upright, so that it may be raised and lowered at will. The end of the glass tube which passes through the cork has a piece of india-rubber tube slipped over it, 15 inches in length, and connected with a ball-syringe, whereby air may be drawn in and discharged again. By heating the metal tube with a spirit-lamp or Bunsen burner, the air discharged by squeezing the ball-syringe will be heated, and may be directed on to the object while under the microscope without any displacement.

Mr. P. J. Butler has employed a somewhat similar apparatus, but of more elaborate construction, for showing the evaporation and condensation of carbonic acid in some of his large specimens. The usefulness of this little instrument will be readily understood when it is mentioned that portions of liquid carbonic acid, so small as not to be recognizable under a magnifying power of 800 diameters, have been revealed by its aid. They could not have been greater than the $\frac{1}{50000}$ of an inch in diameter, and their presence was made known by the instantaneous change in the appearance of the cavities caused by warm air, and then again a reversion to their former appearance by subsequent cooling.

Let us consider what would be the effect of an enormous pressure of rock on carbonic acid heated above its critical temperature: it would be in a condition, as far as we can tell at present, capable of unlimited compression, so that, taking into consideration the comparative incompressibility of water, it would be possible to convert it into a gas with a greater density

than that of water. For instance, at 63°·7 C. (145°·4 F.) under a pressure of 223 atmospheres, the gas has been reduced to $\frac{1}{447}$ of its volume (Andrews, 'On the Physical Properties of Matter,' &c., Proc. Roy. Soc., 1875). Under these circumstances it must be a gas at least as dense, if not denser than water.

Certain specimens of rock crystal containing bubbles of carbonic acid and also other gases floating on water have been heated under mercury to such a temperature that the relative densities of the gas and the water were reversed, and the bubbles sank. In one specimen this change took place at 150° C. (302° F.) It is an effect caused by the expansion of the water, and the consequent compression of the gas in the bubble.

The diamond, which is the densest form of carbon, has never been artificially prepared, and its probable mode of formation has never been satisfactorily explained. It has been supposed to be derived from organic matter by a process of dehydrogenation, the hydrogen being separated from the carbon by the action of moist peroxide of iron and sulphates. A view which is equally tenable is that carbon is separated from carbonic acid, in a very highly compressed condition, by a process of deoxidation, accomplished by alkaline sulphides, metallic iron, or protoxide of iron at moderately high temperatures, or by the mutual reaction of hydrocarbons and highly compressed carbonic acid, which would result in the separation of water and condensed carbon. The combined actions of high temperatures and pressures are conditions under which no chemical reactions have ever been made in the laboratory. To imitate the supposed operations of nature is difficult, because, setting aside the factor time, chemical reactions in the bowels of the earth are reactions carried on under tremendous pressures in sealed tubes of vast thickness.

ARE THE DESMIDS AND DIATOMS SIMPLE CELLS?

By G. C. WALLICH, M.D., Surgeon-Major, Retired List, H.M. Indian Army.

NONE but those who have had long practical experience in microscopical analysis can form an adequate conception of the perplexing difficulties which are inherent in this kind of research. In ordinary investigations connected with natural history, the object to be pronounced upon may be inspected, handled, and tested in every possible way, by any number of persons possessed of average vision and the requisite scientific education, without much risk of their disagreement as to its visible characters. But, unfortunately, a new set of conditions comes into operation when the microscope has to be consulted. To some extent the instrument becomes an arbiter in the matter, and not always a very safe one. Then, it is not merely a good eye, but a good objective,—not merely the requisite scientific knowledge, but the requisite degree of manipulative skill, coupled with the careful training that alone qualifies the observer to distinguish between appearances that are real and those that are spurious and dependent altogether on the methods of examination employed—which have one and all to be secured before trustworthy results can be achieved; whilst the student who happens to be engaged in investigating the minute structure of the lowest organic forms is often confronted at the outset by the additional annoyance of being unable to reconcile what he actually sees in the microscope with what teachers and text-books have taught him that he ought to see. This last-named difficulty is nowhere so strikingly manifest as in studying the structure of these lower forms by the light of the commonly accepted definition of the term "a vegetable cell."

Now it is a singular fact that, although the cell theory undoubtedly constitutes the basis of all histology, and was itself originally propounded with reference to the lowest animal and vegetable types, when brought to bear specially on these very types, it not only breaks down but forces on us the conclusion

that the "primordial simplicity," which has been so constantly referred to as constituting their invariable characteristic, is altogether imaginary. Primordial simplicity may be an essential element in the doctrine of evolution; but such a necessity does not warrant its assumption, as if it were an already demonstrated fact. We know that complex vital processes are carried on even in the lowest types of being. But because we neither know nor are able to conceive *how* they are carried on, we are not justified in taking for granted that what appears to us, even with our most refined appliances, to consist of a mere particle of structureless jelly, must necessarily be as primordially simple as it appears.

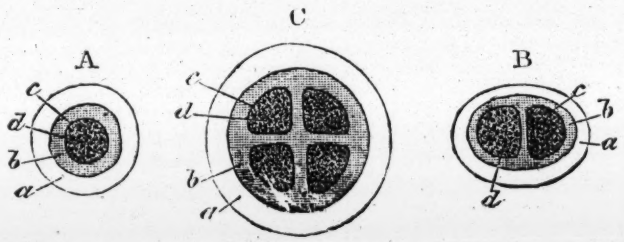
I propose on the present occasion to show that the Desmidiaceæ and Diatomaceæ—well known as these two beautiful groups of organisms are wherever the microscope is employed—are not such simple structures as they are represented to be; and that in this respect they furnish a conspicuous example of the danger of attaching more weight to preconceived theory than to actual structure as it presents itself when seen under sufficiently favourable conditions. But before entering on the inquiry it is indispensable that we should start with a clear idea of the meaning which usually attaches to the term "vegetable cell" when applied to those lowest forms of plant life in which every individual cell, although constituting an integral part either of a symmetrically grouped series, or of a mere colony, is able to maintain a perfectly independent existence.

According to the commonly accepted definition, as given in a recent standard work of reference, such a cell is "a closed sac or vesicle, composed of an *originally* imperforate membrane formed of the substance called cellulose, this membrane enclosing fluid contents so long as the cell retains its vitality"; the word "originally" being obviously inserted in the definition with a view to meet the cases, constantly occurring amongst the higher orders of plants, in which the cell wall is more or less perforate. We are further told that this closed sac or vesicle is of sufficient strength to protect its fluid or semifluid contents; and that it is formed of two quite distinct layers, the innermost of which (the "Primordial Utricle" of Mohl) is identical in composition with the general protoplasmic substance of the organism; whereas the outer layer differs from that substance not only in containing no nitrogen and being closely allied in chemical composition to starch,* but also in not taking part in any of the vital processes which are carried on within the structure.

* As a matter of fact the difference here spoken of is not so great as is represented, inasmuch as starch, in the shape of *dextrine*, is found in the protoplasmic contents.

A good idea may be formed of the appearance of the simpler kind of vegetable cell by an examination of *Protococcus* or *Palmella*, both of these organisms being exceedingly common and obtainable at almost any season of the year. In *Palmella*, as will be seen on reference to the annexed woodcut, fig. 1, the cells are surrounded by an externally investing gelatinous layer, *a*, of which no mention is made in the definition, owing to its being regarded as a mere occasional and supplementary appendage. This view, however, appears to me to be insufficiently established, inasmuch as there is reason to believe that it is present in the unicellular algæ generally, though often in such an extremely attenuated state as to be invisible even with the aid of the highest powers of the microscope; and the evidence of its existence is in these cases derived altogether from analogy and

FIG. 1.



The three figures A, B, and C, represent specimens of *Palmella* before division, after division into two, and these two, after subdivision into four distinct individual cells. The small letters indicate the same parts in each case—*a*, the external jelly-like matrix; *b*, the "primordial utricle" of Mohl; *c*, the cellulose wall; and *d*, the coloured and granular endochrome. It will be seen that the gelatinous investiture does not participate in the division.

observed phenomena in the organisms which are inexplicable on any other supposition than that some external investiture is present. But, apart from the question of its invariable presence, it becomes a matter of great importance to determine whether the gelatinous substance continues, so long as the parent structure lives, to participate in its vitality, or whether it ought to be regarded as effete and dead.* It is so perfectly hyaline and amorphous that the microscope fails to reveal in it the slightest trace of structure. And yet amongst the Diatomaceæ it assumes such a variety of characters, and is in some instances endowed with such a marvellous degree of elastic and contractile power, during the lifetime of the parent organism, *but no longer*, as to suggest the inference that it resists decay and disintegration solely through some vital bond between it and the cell contents.

* The case is probably met by regarding it, in accordance with Dr. Beale's view, as "formed material," although not in the sense of its being devoid of a low degree of vitality.

Advancing a step higher, but still confining myself to structures which avowedly come within the definition of "simple cells," we find in *Closterium*, one of the Desmidiaceæ, that at the period when the frond is just matured, the cavity bounded by the cellulose wall is completely filled with protoplasm; and, so long as the frond is uninjured, this protoplasm presents itself in two somewhat different states; the one, which constitutes the true *endochrome* and the bulk of the cell contents, being of an emerald-green colour and minutely granular; * the other amorphous, almost if not wholly devoid of colour, and constituting (according to my interpretation of the appearances) a thin well-defined but *free* layer between the true cell that surrounds the coloured endochrome and the immediate inner surface of the cellulose or mere protective covering. It is at this point that my interpretation of cell structure (so far as these lowest plant types are concerned) diverges materially from that which has been arrived at by other observers. For whilst it has been customary to regard the surface film of colourless protoplasm as a membrane, or *quasi*-membrane, and to assign it a position, in the normal condition of the organism, immediately in contact with the inner surface of the cellulose wall, I am now prepared to show that, in the Desmidiaceæ, the only portion of the general protoplasmic substance that can with truth be said to constitute either a membranous or *quasi*-membranous investing film does not form part and parcel of the colourless protoplasm, but of the coloured protoplasm or endochrome, by which it is secreted in the shape of a closely investing boundary wall. And, reasoning on this fact as distinctly noticeable in *Closterium*, and other elongate species of the Desmidiaceæ, and on actual observation as regards the changes that take place from time to time within the so-formed cell, it seems legitimate to assume that the colourless protoplasm is solely concerned in the processes of development that go on *exteriorly* to its surface, whilst the true endochrome is solely concerned in the inauguration and establishment of the processes connected with the reproduction and multiplication of the organism which take place within it.

It is true that some writers who have given a great deal of close attention to the subject, altogether deny the existence of any kind of investing membranous structure within the cellulose wall; and describe the portion of the colourless protoplasm, to which the name of "primordial utricle" has been applied, as a "mere pellicle produced by coagulation of the surface of the protoplasm, just as a 'skin' forms over size or other similar

* It is almost superfluous to observe that I abstain from entering into any description of various other minute portions of the structure, solely because these are in nowise connected with the present inquiry.

substances when they dry up in the air." * But, unfortunately, this explanation, although undoubtedly more in consonance with the facts as regards the colourless protoplasm, is based on the assumption that there is no kind of dividing film interiorly to the cellulose wall; and, consequently, that the true endochrome is not separated in any way from the colourless formative layer which is an invariable and most important constituent of the general cell contents.

Again, since distinct apertures are known to exist in the cellulose wall of the Desmid, and the siliceous covering of the Diatom, occurring sometimes as mere minute perforations, sometimes as projecting processes which are distinctly tubular, it is reasonable to conclude that these channels of communication between the exterior and the interior parts serve the purpose of bringing the protoplasmic substance into immediate contact with the medium in which the organisms live, and from which are derived all the materials for their development and growth. And coupling these facts with the indisputable presence, in a large number of the Desmidiaceæ and Diatomaceæ, of a jelly-like secretion, altogether externally to the cellulose and siliceous walls of these organisms, and the difficulty of explaining how this jelly-like secretion is either produced or kept in "working order" otherwise than through being in direct communication with the colourless formative layer through the intervention of the apertures in the protective wall, it appears almost impossible to doubt that the *quasi*-vitality of the gelatinous secretion (or exudation, if this term be preferred) is determinable only by the death of the parent structure.

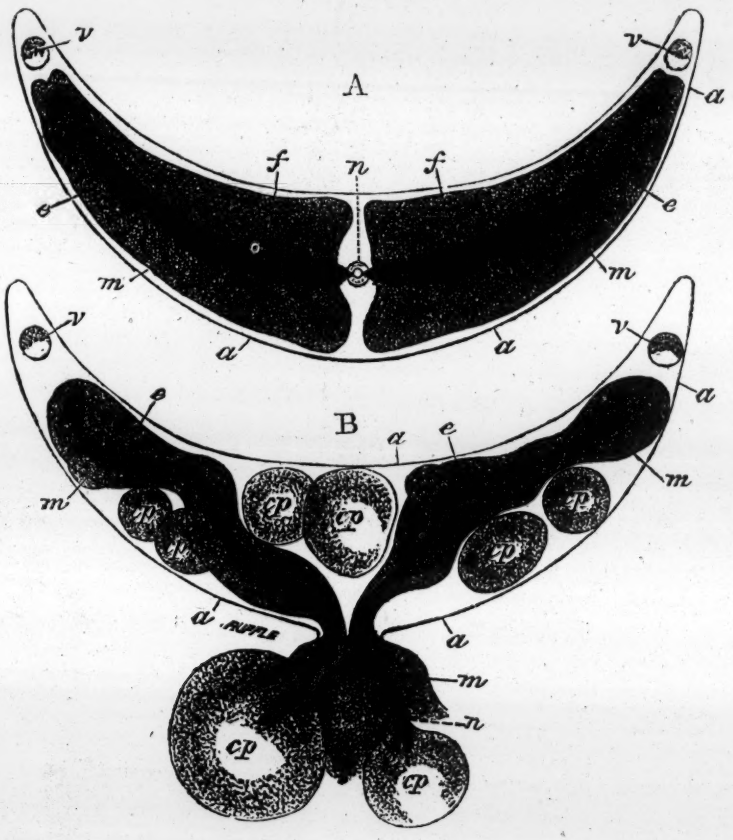
As the evidence furnished by *Closterium* is of a very important kind, it is right to mention that the drawings from which the accompanying figures were copied were made from nature; that no chemical reagents were employed to render the true characters more pronounced, solely in order to avoid the risk of at the same time evoking characters that are factitious; and that the specimen depicted at B, fig. 2, was but one of many similarly crushed, whilst under observation on the stage of the microscope, to show the relation between the cell wall and the several cell contents.

Prior to the application of pressure, the frond (fig. 2, A) presented the following characters. Immediately within the well-defined cellulose wall, *a*, and completely investing its inner surface, was to be seen the thin stratum of amorphous colourless protoplasm, sharply divided on its inner aspect from the masses of brilliant green protoplasm constituting the true endo-

* "Micrographic Dictionary" Third Edition, p. 643.

chrome. The *nucleus*, *n*, with its *nucleolus*, occupied a position at the central part of the frond, where the ends of the dark band of endochrome, *f f*, are seen impinging against it; the usual terminal vesicle, *v*, being present near the apex of each horn of the cellulose crescent. The rupture of the frond took place (as it almost invariably does) at the centre of the convex part; and, at this point, its contents slowly exuded into the water on the slide. Simultaneously with this exudation an

FIG. 2.



A. Frond of *Closterium* in which division has already commenced—*a*, cellulose wall; *n*, *nucleus* resting in the midst of the colourless protoplasm; *e*, endochrome; *m*, investing membrane of endochrome; *v v*, vesicles containing vibratile granules; *f f*, "fillets."

B. Crushed frond of a specimen of the same; *a*, cellulose wall; *e*, endochrome now become slightly granular; *c p*, globules of colourless protoplasm; *n*, *nucleus*; *v v*, vesicles.

entering current of water became distinguishable by the minute particles of foreign matter which were carried in along with it; and the amorphous colourless protoplasm at once broke up into a number of subglobular masses (B, *c p*); the periphery of each of which presented just as close a resemblance to a cell-membrane as the periphery of the sinuous, but still unbroken,

masses of coloured endochrome within the cellulose wall. But so long as retained within it, neither did the globular masses of protoplasm coalesce with the darker masses of endochrome, even when so forcibly squeezed together as to flatten each other to a certain extent; nor did these two portions of the contents mix in the least degree with the water that had gained ingress to the interior of the chamber. Up to this stage, therefore, there seemed just as much reason for assuming that both portions had become, as it were, instantaneously invested with a firm pellicle, as that one or both had, previously to the rupture of the cellulose wall, possessed some such investiture. But the moment the two portions escaped through the ruptured wall, it was only the colourless protoplasmic globules that still retained their perfectly defined outline. The endochrome mass which protruded showed perceptibly (by the irregularity of the freed margin, which could be seen amalgamating slowly with such portions of the globules as happened to be in immediate contact with it) the point at which its investing membrane also had become ruptured. Lastly, on the pressure being increased, simultaneously with the further escape of the contents not only did the cellulose wall become folded and puckered, but portions of the yet retained investing membrane of the endochrome could be distinctly seen within it in a similar condition.

It appears evident, therefore, that the colourless protoplasm exists independently of any special investing wall of its own, and behaves in precisely the same way as sarcode; whereas the true endochrome is encased in an imperforate membranous covering of sufficient strength to resist a considerable degree of pressure and distension before it yields and becomes ruptured; and, being more or less granular, is not so viscid.

I shall now proceed to show how far the facts already adduced in reference to the cell formation in the Desmidiaceæ can be said to furnish a key to that which is to be met with in the most nearly allied family, namely, the Diatomaceæ.

The structure of these organisms is undoubtedly more complex in some respects than that of the Desmidiaceæ, notwithstanding that their general physiological characters, the manner in which the processes of multiplication by "binary division," and of reproduction by the fusion of the protoplasmic contents of two or four cells, the formation of a "sporangium," and the evolution from this body of the germs of an entirely new generation, are virtually identical in the two families.*

Thus (speaking generally) we find the endochrome in both

* See a paper on "The Relation between the Development, Reproduction, and Markings of the Diatomaceæ," by the author, "Monthly Microscopic Journal," Feb. 1877, p. 77.

families more or less brilliantly tinted, green in the one, yellow or greenish-yellow in the other, and at times minutely and sparsely granular; the colourless formative protoplasm existing in a free state within the outer wall; a centrally situated nucleus; terminal vesicles; chlorophyll granules, minute granular masses, the office of which is as yet unknown; oil globules; an outer perforate protecting wall; and lastly, in a large number of species, an external gelatinous matrix.

But although there is this close similarity both in structural and physiological characters, when we come to details some conspicuous peculiarities present themselves in the Diatomaceæ, for which there would appear to be no parallel elsewhere. First and foremost amongst these is the substitution of an inorganic for an organic outer covering; that is to say, one composed of silex, instead of cellulose, which, in some form or other, constitutes the protective and sustaining wall of every other vegetable cell; and the composition of the siliceous covering, not of a single continuous piece like the cellulose covering of the Desmidiaceæ, but of several, and in certain genera an indefinite number of, distinct pieces.*

The twin portions of the Diatom frustule, called the "valves," are, I presume, far too well known to require any description at my hands. But I must mention that, although the valves constitute twin members of the protective covering of the organism, so far as their development is concerned, they are entirely distinct from the "intermediate piece" or "connecting zone," which is developed subsequently to the completion and consolidation of the valves, and is sometimes a permanent, sometimes a supplementary and deciduous portion of the structure.† Hence although the general siliceous covering of the Diatom is undoubtedly the homologue of the cellulose covering of the Desmid, the dual composition of the valves, coupled with the also dual composition of the connecting zone, the overlapping pieces of which slide freely and independently one within the other, renders quite untenable the opinion expressed by some writers, that the connecting zone is the silicified portion of the primordial utricle,‡ "left exposed when the valves recede from each other in order to make room for the increase" just referred to. For, admitting for the sake of argument, that the first developed or innermost of the two overlapping pieces of the connecting zone were thus formed, it is obvious that when this is once consolidated the perfect

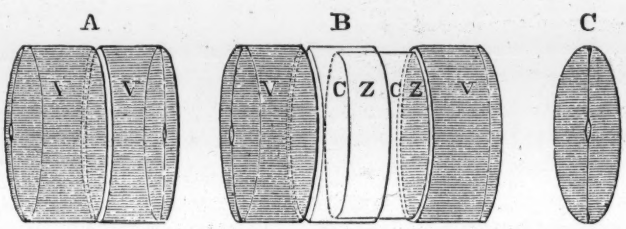
* In "Rhabdonema."

† See paper already referred to.

‡ Of course the term is here used as applying to the superficial layer of protoplasm in immediate contact with the siliceous wall.

rigidity and impermeability of the material would be incompatible with the production, by the same means, of a second independent siliceous layer altogether externally to the first. On the other hand, if we regard the valves and connecting zones as the product of the colourless formative protoplasm which is present not only within the chamber, but sends forth a delicate film to invest exteriorly the already silicified parts (free communication being, as already pointed out, afforded between the contents of the chamber and the surrounding water by means of the apertures in the margins of the valves, and also between the plates of the connecting zones themselves), all difficulty vanishes, and the observed structure of the Diatom frustule becomes forthwith reconcilable with the formative faculty which has, under any view of the case, to be assumed as the agency whereby the mineral secretion is effected. As it is very difficult to make all this clear by mere description, I have endeavoured to give a general idea of the structure of the Diatom frustule, and the relations of the valves and connecting zones to each other, by the subjoined diagram, fig. 3.

Fig. 3.

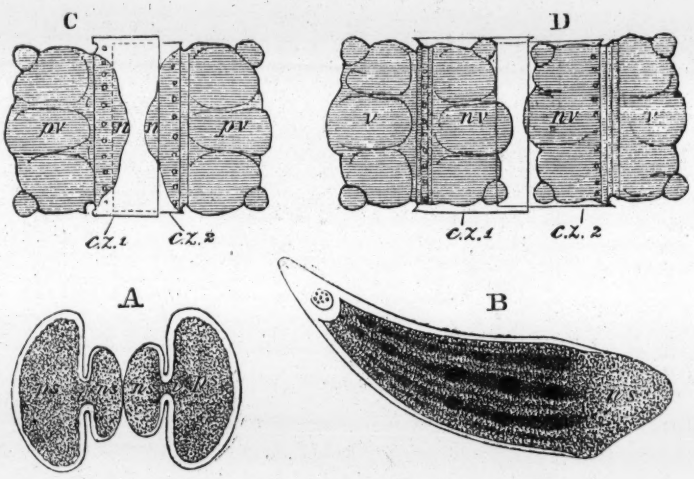


A. Front view of a naviculoid Diatom frustule when just completed, and before division has begun to take place. The central double line represents the two valvular margins; *v v*, the two valves.
B. The same frustule when division is taking place, and the connecting zones *c z*, *c z*, have been formed.
C. Front view of one of the valves of same.

It has already been seen that in the Diatomaceæ, as in the Desmidiaceæ, there exists the same division of the protoplasm into a colourless formative portion, and one more or less brilliantly coloured which constitutes the true endochrome, and contains within its substance the laboratory and materials, so to speak, which are requisite in the processes of division and reproduction. In the just *completed* frond of the Diatom the true endochrome occurs in two halves, each of which is so perfectly distinct in outline as to warrant the conclusion (when coupled with what has been noticed as being the case in the Desmid) that it is in like manner enclosed by an investing wall, although the extreme tenuity of this has heretofore prevented it from being distinguished. But it is well to bear in recollection that in the

Desmid the endochrome of the parent cell constitutes a continuous mass till division takes place, this being the only condition under which the protoplasmic material for the two new valves about to be formed could be exuded from the divided surfaces; for, obviously, no exudation could take place were these surfaces already sealed by the closing in of the membranous investment. But whereas in the Desmid the development of the cellulose covering proceeds simultaneously with the exudation of the young segment, becoming thicker and firmer as

FIG. 4.



A. A frond of a Desmid, namely *Cosmarium*, in which division is about one-third completed. *p s*. *p s*, the two parent segments normally separated by a deep notch; *n s*, *n s*, the two young segments being budded forth from the narrow but open passage *i i*, by which the parent segments were held together like Siamese twins.

B. A segment of a *Closterium*, in which genus the segments part company at a very early period; *n s* being the incipient young segment which is being budded forth as in the last case.

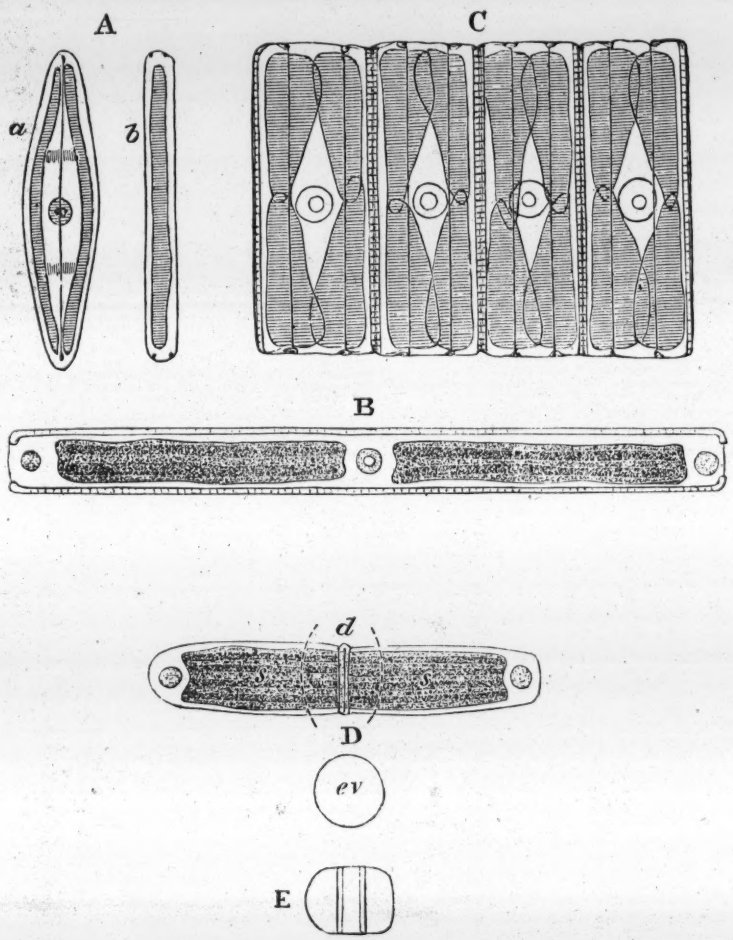
C. A frustule of a Diatom, *Biddulphia*, about half-way advanced in the process of division—*p v*, *p v*, the parent valves; *n n*, the endochrome masses being budded forth, precisely as in the Desmid, from the open surface of the divided cell contents; *c z*, *c z*, the two connecting zones sliding apart, one within the other, telescope fashion, to accommodate themselves to the increasing bulk of the cell contents during division.

D. The same, division being completed, and the two perfect and consolidated siliceous valves, *n v*, *n v*, shown within the still persistent connecting zones which had protected them during their development.

the process advances; in the Diatom the secretion of the siliceous wall does not commence at all until the soft plastic protoplasm of which the new valve is to be formed, has already attained its full proportions and figure. This fact admits of a ready explanation, inasmuch as the unyielding nature of the siliceous coat, however thinly it may be deposited, would effectually bar all further development of the soft parts, were the siliceous deposit to begin at any stage anterior to that above described. (See fig. 4, in which the process of development of the new

segments in the Desmid and the new valves in the Diatom are represented as taking place).

Fig. 5.



A. *a*, front view of a valve of *Navicula*, showing the endochrome arranged in two longitudinal lamellæ along the margins of the valve; *b*, front view of the *frustule*; when dividing, the endochrome here seen will divide longitudinally along its centre.

B. Front view of *frustule* of *Nitzschia*, showing the endochrome in this view as if it consisted of only two portions; the nucleus centrally situated, and the terminal vesicles at the extremities, precisely as in *Closterium* (fig. 2). The peculiarity of this genus consists in the endochrome being divided into four lamellæ, not parallel with the plane of the valves, but of the connecting zones.

C. A short filament of *Himantidium*, showing the curious fourfold curtain-like arrangement of the true endochrome, the nucleus as usual central.

D. *d*, front view of a frond of *Docidium*, a Desmid, intended to show that by cutting off the ends of the segments, *s s*, at the points indicated by the dotted lines, the front view would closely resemble the front view of the frustule of *Melosira* (a *Diatom*), of which the outline is given as E, the sectional outline or end view of the *Docidium* being represented as *e v*.

In the Diatom, as soon as division is completed, the true endochrome of each frustule splits up into two, and in some genera four, lamellar masses, each of which, from its remaining

unaltered in outline for a considerable period, would appear to have its own investing covering. But these masses, instead of occupying a position along the central region of the general chamber, are suspended, as it were, in the colourless protoplasm within, but not in immediate contact with the inner surface of the valve and connecting zone; the middle of the chamber, together with the space intervening between the lamellæ of endochrome, and the inner surface of the siliceous wall being occupied, just as in the Desmid, by colourless protoplasm.

On cursorily looking at a Diatom frustule—say of a *Navicula*—it might easily be supposed that the relative positions of the true endochrome and the siliceous wall, both before and after division, differ from those which obtain in the Desmid frond. Indeed, this mistake is a common one, due to the overlooked fact that, as a rule, division takes place in the Diatom in a plane which bisects the shortest axis of the organism; whereas, in the Desmid, it takes place in a plane bisecting the longest axis. In other words, the tranverse or short axis of the Diatom *frustule*, coincides with a line passing across the centres of *both* its valves; whereas the longitudinal axis of the Desmid *frond* corresponds with a line passing through the centre of both its *segments*. Or, to state the case in still another way, the front view of the Diatom *valve* (see fig. 5, A, *a*) corresponds with the end view of the frond or segment of the Desmid (D, *e v*); whereas the front view of the Diatom frustule (A, *b*, or C), and the front view of the Desmid frond (fig. 4, A, and fig. 5, D, *d*), represent corresponding aspects in the two kinds of organisms. This last-named correspondence of parts will be best understood, however, by comparing the figures of *Docidium* (a Desmid) fig. 5, D, *d*, with the front view of *Melosira*, a cylindrical but short Diatom, of which an outline representation is given at E.

Lastly, I have to touch briefly on the subject of the extra-frustular appendages as these present themselves in the Diatomaceæ. They may consist merely of a gelatinous mass, more or less shapeless, in which a colony of frustules is imbedded, as in *Dickieia*; of a tubular sheath of almost horny consistence, though perfectly hyaline, in which the separate frustules move freely, as in *Encyonema*; of stalk-like processes or pedicels which anchor the frustules to the substance from which they spring, as in *Cocconema*, or which constitute a kind of stem to a broad, fan-like expansion of frustules, as in *Licmophora*; of mere pads which connect the frustules of certain filamentous forms to each other, as in *Biddulphia*; of a highly elastic and yet subtle film which completely invests some of the filamentous bacillarian forms, and at the same time either permits of their peculiar movements, or itself contributes to the performance of these movements, as in that most remarkable of all Diatoms,

Bacillaria paradoxa; and lastly, of a flattened, quoit-shaped, hyaline expansion, surrounding the periphery of each valve, as in the beautiful oceanic Diatom, *Coscinodiscus sol.* Many more forms of these appendages might be enumerated differing as widely from each other as the above, not only in shape but in the purposes they apparently serve in the economy of the several species which possess them. I presume, however, that enough has been advanced to substantiate what I contend for—namely, that it is illogical to regard all these widely varying phases of this extra-frustular secretion as unconnected with some more specialized function in the protoplasm of the Diatom than has hitherto been ascribed to it. The different forms assumed cannot be fortuitous. Their permanence in certain species, and in these only, at once negatives any such idea. For the same reason it is hardly possible that they can be epiphytic or parasitic growths, which have nothing to do with the structure with which they are associated. Their perishable nature the moment the parent structure dies would almost seem to prove that they cannot be looked upon as absolutely effete matter whilst constituting an integral part of the living organism. The siliceous wall of the Diatom may be dead matter, just as dentine is, though still forming part of the living animal. But both these portions of structure are almost imperishable under ordinary conditions. There is, therefore, no analogy between the cases.

Of the movements observable in certain Diatoms much might be said that bears in an important degree on the present subject. For the present I must, however, rest content with repeating the conviction expressed by me nearly twenty years ago, in the "Annals," and again very recently in the "Monthly Microscopical Journal," that so palpably are these movements due to some subtle form of motile filaments that I do not hesitate to say it is but a question of time and properly directed skill when the nature of the organ, whatever its exact form may be, shall be revealed by the microscope, just as the long-suspected flagellum of one of the *Bacteria* has already been.

It only remains for me to add that, taking all the forthcoming facts into consideration, many of the most material of which my limits have precluded me from even naming in the present article, there seems to be ample ground for concluding that the Desmid and the Diatom, although undoubtedly presenting "closed-cells" within their structure, are not themselves mere cells consisting only of the parts, or homologues of the parts, which enter into the composition of the typical vegetable cell as ordinarily defined; but are, in reality, composite structures of which the cellular portion constitutes a small, though no doubt a very important, integral part.

LEMMINGS IN MIGRATION.

THE NORWEGIAN LEMMING AND ITS MIGRATIONS.

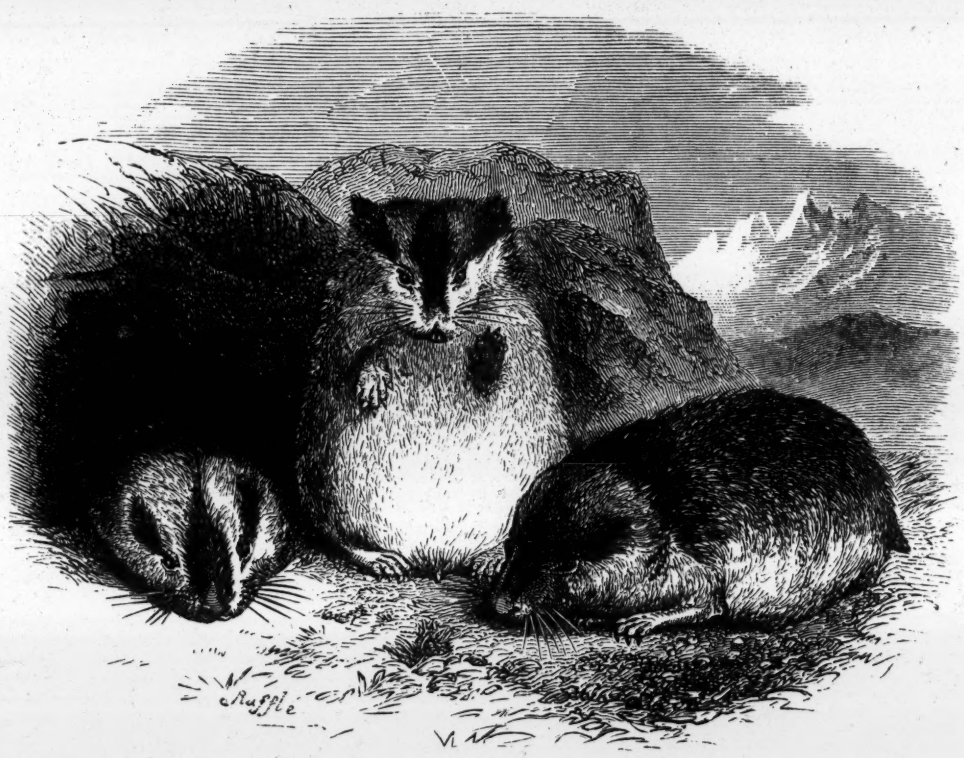
By W. DUPPA CROTCH, M.A., F.L.S.

[PLATE IV]

AMONG the many marvellous stories which are told of the Norwegian lemming (*Myodes lemmus*, Linn.) there is one which seems so directly to point to a lost page in the history of the world that it is worth a consideration which it appears hitherto to have escaped. I allude to the remarkable fact that every member of the vast swarms which periodically almost devastate Norway perishes voluntarily, or at least instinctively, in the ocean. But as among my readers some may not be familiar with the lemming, a brief description of the animal itself will not be out of place. It is a vole, like our short-tailed field mouse, very variable in size and colour, but the figures (fig. 1), which are about half the natural size, will be found to resemble the majority in the latter respect. The claws, especially on the fore foot, are strong and curved, the tail is very short, the ears scarcely visible, and the beadlike, black eyes seem always to notice objects above them rather than those in any other direction. During the summer these animals form their nests under stones, usually betraying their habitations by the very care which they take to keep them sweet and clean. In winter, however, they form long galleries through the turf and under the snow in search of their food, which is exclusively vegetable; and it is at this time that those ravages are caused which have led the Norwegians in former times to institute a special form of prayer against their invasions. There are several species of lemming, easily recognizable, and with well-marked geographical range; but it is to the Scandinavian species only that the following old description applies. "It lives on the shoots of the dwarf birch, reindeer lichens, and other mosses; it hisses and bites; in winter it runs under the snow; and about every tenth year, especially before an extremely severe winter, the whole army of animals, in the autumn and at night, migrates in a direct line." According to Olaus Magnus they fall from the clouds; and Pennant narrates that "they descend from the Kolen, marching in parallel lines three

feet apart; they traverse Nordland and Finmark, cross lakes and rivers, and gnaw through hay and cornstacks rather than go round. They infect the ground, and the cattle perish which taste of the grass they have touched; nothing stops them, neither fire, torrents, lakes nor morasses. The greatest rock gives them but a slight check; they go round it, and then resume their march directly without the least division. If they meet a peasant they persist in their course, and jump as high as his knees in defence of their progress. They are so fierce as to lay hold of a stick and suffer themselves to be swung about

Fig. 1.



GROUP OF LEMMINGS.

before they quit their hold. If struck they turn about and bite, and will make a noise like a dog. Foxes, lynxes, and ermines follow them in great numbers, and at length they perish, either through want of food or by destroying one another, or in some great water, or in the sea. They are the dread of the country, and in former times spiritual weapons were exerted against them; the priest exorcised them, and had a long form of prayer to arrest the evil. Happily it does not occur frequently—once or twice only in twenty years. It seems like a vast colony of emigrants from a nation overstocked, a

discharge of animals from the northern hive which once poured forth its myriads of human beings upon Southern Europe. They do not form any magazine for winter provision, by which improvidence, it seems, they are compelled to make their summer migration in certain years, urged by hunger. They are not poisonous, as vulgarly reported, for they are often eaten by the Laplanders, who compare their flesh to that of squirrels."

M. Guyon disposes of the theory that these migrations are influenced by *approaching* severe weather, since the one witnessed by himself took place in the spring; also the superabundance of food during the previous autumn precluded all idea of starvation. He therefore adopts a third view, that excessive multiplication in certain years necessitates emigration, and that this follows a descending course, like the mountain streams, till at length the ocean is reached. Mr. R. Collett, a Norwegian naturalist, writes that in November, 1868, a ship sailed for fifteen hours through a swarm of lemmings, which extended as far over the Trondhjems-fjord as the eye could reach.

I will now relate my own experience of the lemming during three migrations in Norway, and in a state of captivity in England. The situation of Heimdalen, where I reside during the summer months, is peculiarly well suited for observation of their migrations, lying as it does at an elevation of 3,000 feet, and immediately under the highest mountains in Scandinavia, and yet, excepting during migration, I have never seen or been able to procure a specimen. It was in the autumn of 1867 that I first heard the peculiar cry of the lemming, guided by which I soon found the pretty animal backed up by a stone, against which it incessantly jerked its body in passionate leaps of rage, all the while uttering a shrill note of defiance. The black, beadlike eyes seemed starting from their sockets, and the teeth shone white in the sunlight. I hastily snatched at the savage little creature, but it sprang completely round, fastened its teeth sharply in my hand, and taking advantage of my surprise escaped under a large stone, whence I could not dislodge it. A Norwegian friend who accompanied me by no means shared my feelings of satisfaction at the sight of a lemming. "We shall have a severe winter and no grass next spring owing to those children of Satan!" was his comment on the event. However, it was many a month before I saw another, then, on lifting a flat stone I found six in a nest of dried grass, blind, and apparently but just born. In a few days the whole fjeld became swarming with these pretty voles; at the same time white and blue foxes made their appearance, and snowy owls and many species of hawks became abundant. My dogs, too, were annoyed by the rash courage of the new comers,

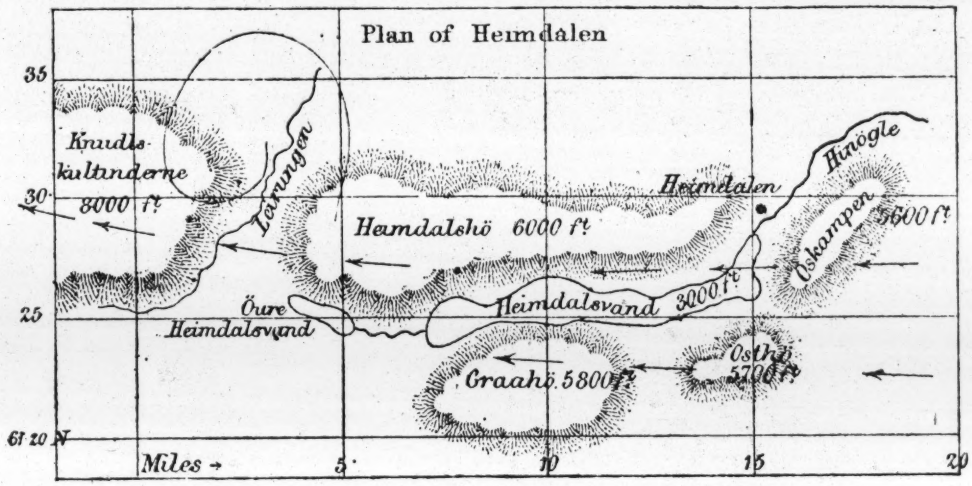
which would jump at their noses even when slowly drawing on game, so that they never spared a lemming, though they never ate them till last year, when I observed that they would eat their heads only, rejecting the body, although they devoured the common field mouse to the end of his tail. As the season advanced and snow covered the ground, the footprints and headless carcasses told plainly how hard it must be for a lemming to preserve its life, although there can be no doubt that its inherent pugnacity is its worst enemy. In this country we fail to conceive how much active life goes on beneath the snow, which in more northern latitudes forms a warm roof to numerous birds, quadrupeds, and insects, which are thus enabled to secure an otherwise impossible sustenance. At the same time, as I have already noticed, a fearful struggle for existence is carried on during the long autumnal nights before the snow has become a protection rather than a new source of danger to all save predaceous animals. It was a curious sight, when the whole visible landscape was of an unbroken whiteness, to see a dark form suddenly spring from the surface and scurry over the snow, and again vanish. I found that some of the holes by means of which this feat was executed were at least five feet in depth, yet even here was no safety, for the reindeer often kill the lemmings by stamping on them, though I do not believe their bodies are ever eaten.

During the autumn I noticed no migration, or rather there was only an immigration from some point to the eastward, and in the subsequent migrations of 1870-1 and 1875-6 I still found the same state of things. The animals arrived during early autumn, and immediately began to breed; there was no procession, no serried bands undeterred by obstacles, but there was an invasion of temporary settlers, which were speedily shut out from human view by the snow, and it was not till the following summer that the army, reinforced by five or six generations, went out to perish like the hosts of Pharaoh. On calm mornings my lake, which is a mile in width, was often thickly studded with swimming lemmings, every head pointing westward, but I observed that when my boat came near enough to frighten them they would lose all idea of direction and frequently swim back to the bank they had left. When the least wind ruffled the water every swimmer was drowned, and never did frailer barks tempt a more treacherous sea, as the wind swept daily down the valley, and wrecked all who were then afloat. It was impossible not to feel pity for these self-haunted fugitives. A mere cloud passing over the sun affrighted them; the approach of horse, cow, dog, or man alike roused their impotent anger, and their little bodies were convulsively pressed against the never-failing stone of vantage (see fig. 1), whilst

they uttered cries of rage. I collected 500 skins, with the idea of making a rug, but was surprised to find that a portion of the rump was nearly always denuded of hair, and it was long before I discovered that this was caused by the habit of nervously backing up against a stone, of which I have just spoken. As this action is excited by every appearance of an enemy it seems surprising that a natural callosity should not take the place of so constant a lesion; possibly, however, the time during which this lesion occurs is too short to cause constitutional change.

Early in the autumn, and just a year after their arrival at Heimdalen, the western migration commenced anew. Every

FIG. 2.



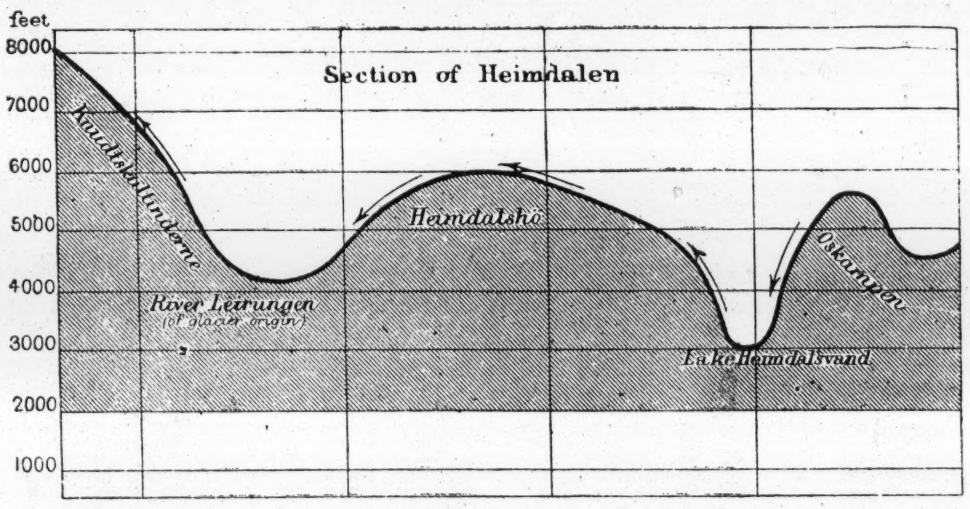
Plan of Heimdalen drawn to scale, in which the course of the Lemmings, indicated by the arrows, is seen to cross Lake Heimdalsvand and the swift river Leirungen, both of which might be avoided by a slight détour. The river is of glacier origin, very cold and very rapid.

morning I found swarms of lemmings swimming the lake diagonally instead of diverging from their course so as to go round it, and mounting the steep slopes of Heimdals-hö (figs. 2 and 3) on their way to the coast, where the harassed crowd, thinned by the unceasing attacks of the wolf, the fox, and the dog, and even the reindeer, pursued by eagle, hawk and owl (See Pl. IV.), and never spared by man himself, yet still a vast multitude, plunges into the Atlantic Ocean on the first calm day, and perishes with its front still pointing westward. No faint heart lingers on the way; and no survivor returns to the mountains.

There appears to have been a difficulty in keeping these restless creatures in captivity, both because they escape through in-

credibly small apertures (generally, however, dying from internal injuries thus caused), and because they will gnaw through a stout wooden cage in one night, and devote every spare moment to this one purpose, with a pertinacity worthy of Baron Trenck. At all events, few have been brought alive to this country, and none have survived. At present (February, 1877) I have one which I have preserved since September last, defeating his attempts at escape by lining the cage with tin, and allowing him a plentiful supply of fresh water, in which he is always dabbling. With the approach of winter all his attempts to escape ceased, and I now always take the little stranger for an airing in my closed hands whilst his bed is being made and his room cleaned out. He seems to like this, but after a few minutes a gentle nibble at my finger testifies to his impatience, and if this be not attended to the

FIG. 3.



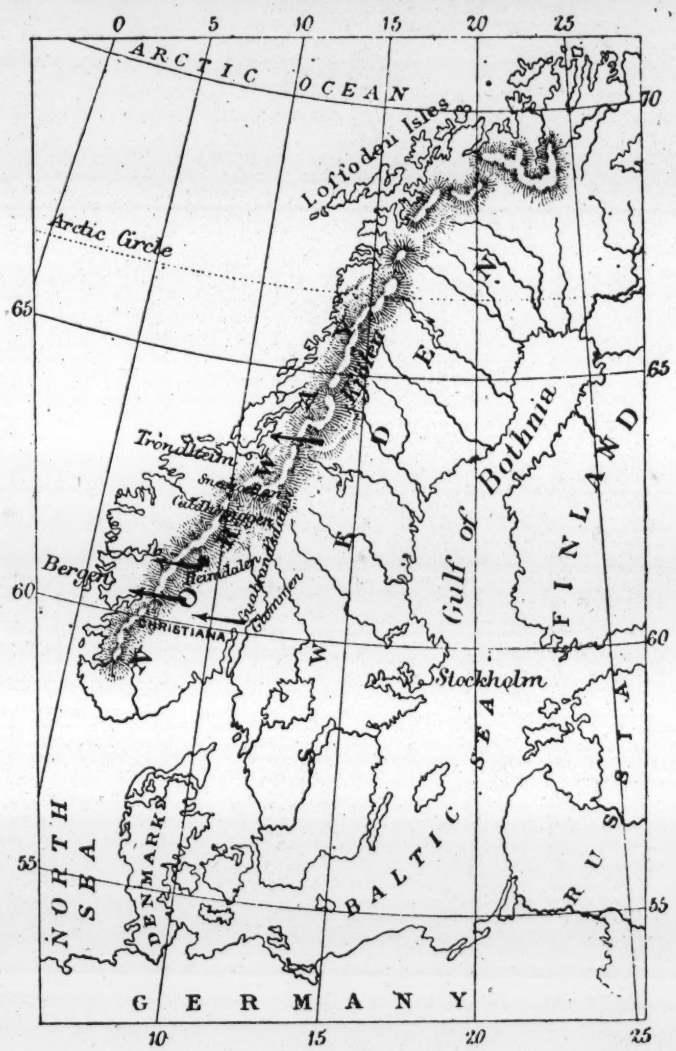
Section of Heimdalen showing the Lemmings' track, which does not follow the watershed.

biting progresses in a crescendo scale until it becomes unbearable, although it has never under these circumstances drawn blood. My little prisoner shows few other signs of tameness, but the fits of jumping, biting, and snarling rage have almost ceased. I expect, however, that with the return of spring the migratory impulse will be renewed, and that he will kill himself against the wires of his cage like a swallow.

The reader is now in a position to consider the three questions raised by the above facts, and those questions are as follow:— 1. Whence do the lemmings come? 2. Whither do they go? 3. Why do they migrate at all? With regard to the first, no one has yet supplied an answer. They certainly do not exist in my neighbourhood during the intervals of migration; and the Kjolen range was probably selected as their habitat, not because

it was proved to be so, but because so little is known about it at all. The answer to the second question is certain: they go to the sea. Those on the east of the backbone of Norway go to the Gulf of Bothnia, and those on the west to the Atlantic Ocean (fig. 4), and out of 18 migrations which have been investigated, one only, and that very doubtful, is reported

FIG. 4.



Outline map of Scandinavia. The two main valleys, Gudbrandsdalen, and the valley of the Glommen, run nearly north and south. The course of the Lemmings crosses there at right angles, as indicated by the arrows.

to have been directed southward. The question as to the cause of these migrations remains, and is a very difficult one to answer. We have been told that the foreknowledge of approaching severe weather predetermines the exodus: my experience, however, contradicts this, and it may be dismissed as merely a popular superstition. Unusual reproduction and

consequent deficiency of food is a more plausible theory, but I have always noticed that, just as with the swallow, a few individuals have preceded the main body, and that during the first autumn the numbers are never large, but after a winter spent beneath the snow they begin to breed with the first days of summer, and thus develop the extraordinary multitude which is, as it well may be, the astonishment and terror of the country. It appears, then, that excessive reproduction is rather the result than the cause of migration. It has also been suggested that the course taken by the lemmings follows the natural declivities of the country, but a reference to the maps will show that in that case nearly all the Norwegian migrations should take a southerly route, which is by no means the case. On the contrary, westward at Heimdal means across a rapid river, over a wide lake, and up a steep, rocky and snowy mountain, and this is the course which is followed. Now, this ends eventually in the ocean, and thus we are again landed at the question from which we set out. After all, it is not the power of direction which is so remarkable: this is a faculty possessed by many animals, and by man himself in a savage state. A young dog which I took from England, and then from my home in Vaage by a path to Heimdalen, a distance of 46 miles, ran back the next morning by a direct route of his own, crossing three rapid rivers and much snow, and accomplishing the distance in six hours, without the vestige of a path. This same dog afterwards repeated the feat, but followed the path, and took two days in reaching his destination, hindered and not aided, as I believe, by his experience. Herr Palmén, indeed, says "experience guides migration, and the older migrants guide the younger," like one of Mr. Cook's personally conducted tours. This obviously cannot be the case with the lemmings.

It is now generally admitted that instinct is merely inherited experience, and is therefore primarily calculated to benefit the species, unless indeed circumstances have changed meanwhile more rapidly than the structures to which the phenomena of instinct are due. Now, the lemmings during their wanderings pass through a land of milk and honey, where, if their instincts could be appeased, they might well take up a permanent abode, and yet they pass on, whilst their congener, the field-vole, remains in quiet possession of the quarters from which he was temporarily ousted. It is indeed almost as strange a sight to see the holes, the deeply-grooved runs, and the heaps of refuse of these restless creatures, which have passed away but yesterday, as it is to see the fjelds suddenly become alive with a new and boisterous tenant, who, like another Ishmael, has the hand of all men against him.

Now, if we compare the migration of the lemmings with that

of our more familiar swallows, we find that the latter obviously seek a more genial climate and more abundant food, returning to us as surely as summer itself; nor do they ever, so far as I know, breed on their passage. The swifts, which stay but a short time with us, remain in Norway barely long enough to rear their young before returning to Africa. It is difficult, in fact, to find a parallel case to that of the lemmings: the nearest approach, perhaps, is afforded by the strange immigration of Pallas's sand-grouse in 1863, when a species whose home is on the Tartar Steppes journeyed on in considerable numbers to the most western shores of Europe, and very probably many perished, like the lemmings, in the waves of the Atlantic. But to revert to the swallows, which annually desert Europe to visit Africa. Let us suppose that these birds were partial migrants only—that is, that a remnant remained with us after the departure of the main body—and further suppose that the continent of Africa were to become submerged, would not many generations of swallows still follow their inherited migratory instincts, and seek the land of their ancestors through the new waste of waters, whilst the remaining stock, unimpeded by competition, would sooner or later, according to the seasons, recruit the ranks for a new exodus? It appears quite as probable that the impetus of migration towards this lost continent should be retained as that a dog should turn round before lying down on a rug, merely because his ancestors found it necessary thus to hollow out a couch in the long grass.

Well, then, is it probable that land could have existed where now the broad Atlantic rolls? All tradition says so: old Egyptian records speak of Atlantis, as Strabo and others have told us. The Sahara itself is the sand of an ancient sea, and the shells which are found upon its surface prove that no longer ago than the Miocene period a sea rolled over what now is desert. The voyage of the "Challenger" has proved the existence of three long ridges in the Atlantic Ocean, one extending for more than three thousand miles; and lateral spurs may, by connecting these ridges, account for the marvellous similarity in the fauna of all the Atlantic Islands. However, I do not suppose that the lemmings ever went so far south, though they are found as fossils in England; but it is a remarkable fact that whilst the soundings off Norway are comparatively shallow for many miles, we find a narrow but deep channel near Iceland, which probably has prevented the lemming from becoming indigenous there, although an American species was found in Greenland during the late Arctic Expedition. If, as is probable, the Gulf Stream formerly followed this deep channel, its beneficent influence would only extend a few miles from the coast, which would also have reached to a great

distance beyond the present shores of Norway, and thus the lemmings would have acquired the habit of travelling westward in search of better climate and more abundant food; and as little by little the ocean encroached on the land the same advantages would still be attained. And thus, too, we find an explanation of the fate which befalls the adventurous wanderers; for we have already seen that no lake deters them, and that they frequently cross the fjords, or arms of the sea, in safety. No doubt, therefore, they commit themselves to the Atlantic in the belief that it is as passable as those lakes and fjords which they have already successfully dared, and that beyond its waves lies a land which they are never destined to reach.

The submerged continent of Lemuria, in what is now the Indian Ocean, is considered to afford an explanation of many difficulties in the distribution of organic life, and I think the existence of a Miocene Atlantis will be found to have a strong elucidative bearing on subjects of greater interest than the migration of the lemming. At all events, if it can be shown that land existed in former ages where the North Atlantic now rolls, not only is a motive found for these apparently suicidal migrations, but also a strong collateral proof that what we call instincts are but the blind and sometimes even prejudicial inheritance of previously acquired experience.

THE ALKALINE AND BORACIC LAKES OF CALIFORNIA.

By J. ARTHUR PHILLIPS, F.G.S.

IMMEDIATELY east of the range of the Sierra Nevada is an extensive region of alkaline lakes and hot springs, of which very large areas are almost totally barren, the only vegetation consisting of wild sage, yucca, a few cacti, and scanty tufts of bunch-grass.

This district affords, in its many extensive craters and in its lavas, basalts and obsidians, the most conclusive evidence of its volcanic origin, while its solfataras and boiling springs may be regarded as the last representatives of active vulcanicity.

Although this region is one of great scientific interest, and may eventually become industrially important, it appears to be but little known in this country, and it has therefore been thought that a brief description of the district, as well as of that of the borax lakes, lying on the western side of the Sierra, might not be without interest to English readers.

The most remarkable of the alkaline lakes of this portion of California are Mono and Owen's Lakes. The former lies in a depression occupying a portion of an elevated plateau of desert land, situated at the eastern base of the Sierra Nevada between the head waters of Owen's and Walker's Rivers. The distance from the summit of the range to the lake-shore is about six miles, and the difference of elevation is about 6,000 feet. On all sides, excepting towards the Sierra, this lake is surrounded by a wide belt of desert, the total area of which is from 400 to 500 square miles.

Mono Lake is about fourteen miles long, from east to west, and nine wide, from north to south; but it was formerly much larger than it is at present; this is indicated by numerous terraces, by means of which the lines of its ancient shores may be readily traced.

The water of this lake, which has a high specific gravity, and is alkaline and extensively saline, is not easily thrown into

waves, but is generally smooth and glassy. Near its north shore there are springs which have produced extensive deposits of tufa, some of which rise several feet above the surface in forms resembling gigantic fungi.

There are numerous islands in this lake, two of which are of considerable size, the largest being two and a-half miles long, from north to south, and the other about half a mile in length, from east to west. These, as well as a group of smaller islets lying to the north, are entirely composed of volcanic materials.

On the north-eastern corner of the larger island are extensive hot springs and steam-jets, covering an area of some thirty acres, and extending into the lake. The escape of steam and hot gases from so many hundreds of vents is attended with much noise, and the sides of the orifices of many of the fumaroles are incrusted with a reddish-brown substance, which is probably chloride of iron. In the neighbourhood of these springs there is a slight smell of sulphurous acid, but no free sulphur is deposited. Some of them furnish a copious supply of boiling water, large quantities of which enter the lake, and so perceptibly raise its temperature for a considerable distance around. Much gas and steam escape from a fissure caused by the sinking of a portion of the crust, while on the eastern part of the island are two well-defined craters, now filled with water.

Mono Lake is, during the summer, the resort of myriads of gulls and other aquatic birds, which are most numerous during the breeding season, but the water is believed to be entirely destitute of life, with the exception of a small crustacean, *Artemia fertilis*, nearly related to the so-called brine shrimp (*Artemia salina*) found in the strong brine of the salt pans on European coasts, and the *Koo-chah-bee* of the Indians, a whitish larva, occurring in immense quantities, and which is much esteemed by them as an article of food.

Stretching south of the lake is a chain of extinct volcanoes, presenting the form of truncated cones, of which the generally steep sides are covered with ashes and other loose materials. Obsidian and pumice are abundant on the surface of these cones, and also cover the plains at their base.

Owen's Valley is a narrow basin lying south of Mono Lake, and running nearly north and south for a distance of about 140 miles. Its average width may be taken at ten miles. It is bounded along its western edge by the Sierra Nevada, which in this portion of its course presents an almost unbroken wall, of which the highest peak, opposite Owen's Lake, reaches an elevation of 15,000 feet. No pass crosses it at a less height than 11,000 feet, and near the lake-shore the descent from the summit to the valley beneath must have an average inclination of at least 1,000 feet per mile, the distance being from ten to eleven

miles, and the difference of level between the highest point of the pass and the valley being from 10,500 to 11,000 feet.

On the eastern side of this valley are the Inyo Mountains, towards its southern end, and the White Mountains further north. This range is dry and desert-like, and not a single stream of any size flows from it into Owen's Valley, which is exclusively watered by the melting of the snows accumulated during the winter months on the eastern slope of the Sierra. Owen's River rises a short distance from the source of the San Joaquin, and, after flowing for a distance of 120 miles, falls into Owen's Lake in lat. 36° 20′ N., long. 118° W. from Greenwich. This lake, of which the water is exceedingly saline and strongly alkaline, is twenty miles long and eight wide. It has no visible outlet, and its shores are often thickly coated with a snow-like alkaline incrustation.

No fish inhabits its waters, but *Koo-cha-bee* is abundant, and at certain seasons is carried in by the waves and deposited on the shores in layers of several inches in thickness. This was formerly collected in large quantities by the Indians, and, after being dried in the sun, rubbed between the hands and roughly winnowed, was crushed in a stone mortar, and made into a sort of bread, which furnished an important article of food. This insect, which has been described as a white grub, is also found abundantly in the waters of Great Salt Lake, Utah, and those of other saline and alkaline lakes of the west, and appears to be the larva of a two-winged fly which is described by the late Professor Torrey under the name of *Ephydra californica*, and by Dr. A. S. Packard as *Ephydra gracilis*.*

A specimen of water taken from Owen's Lake, in January, 1866, had a specific gravity of 1·076, and contained 7128·24 grains of solid matter per gallon. The composition of this residue was found, calculated on an imperial gallon, to be as follows:—

Chloride of sodium	2942·05
Sulphate of sodium	956·80
Carbonate of sodium	2914·43
Sulphate of potassium	122·94
Phosphate of potassium . . .	35 74
Silicate of potassium	139·34
Organic matter	16·94
	7128·24

In addition to the substances above enumerated, iodine was present, but only in such minute proportion that its amount

* See Hayden, "Geological Survey of Montana, Idaho, Wyoming, and Utah, 1872," p. 744.

could not be estimated. It is also to be observed that since, for convenience of carriage, the sample of this water operated on was reduced by evaporation to one-fourth of its original bulk before being brought to this country for analysis, it is probable that some alkaline sesquicarbonates may have been originally present.

The incrustations which at certain periods of the year accumulate to the extent of many hundreds of tons on the shores of this lake, mainly consist of carbonates of sodium, in which the proportion of sesquicarbonate is somewhat variable; in some specimens examined monocarbonates were alone present. Besides carbonates of sodium, these deposits contain 3 per cent. of chloride of sodium, and about 5 per cent. of sulphate of sodium, together with traces of silica.

It was proposed some years since to erect works on the eastern shore of Owen's Lake, for the purpose of refining this deposit, for the manufacture of merchantable carbonate of sodium; but whether this idea was ever carried out, I am not aware. The only serious obstacles to the success of such an enterprise would appear to arise from scarcity of fuel, and the great distance of the lake from a shipping port.

As this lake continuously receives the waters of a considerable and constantly flowing river, while it has no apparent outlet, it follows that it must act the part of a huge evaporating basin, in which the salts introduced by the not apparently saline water of Owen's River become concentrated to an alkaline brine. The rocks on either side of the valley through which the river flows are, to a very large extent, composed of granites, lavas, and basalts, from the decomposition of the felspars in which the alkaline salts of the lake have doubtless been derived. The very small proportion of potassium salts present in these waters is remarkable, for although from the circumstance of the felspars of the district being to a large extent triclinic, sodium might be expected largely to predominate, still so great a disproportion in the respective amounts of the two alkalies could scarcely have been anticipated. This circumstance may perhaps, to some extent, be accounted for by supposing the potassium salts to have been largely assimilated by plants during the percolation of the waters containing them through vegetable soil, while the salts of sodium, not having been thus arrested, have passed into the river, and thence into the lake.

Owen's, like Mono Lake, was at one time much more extensive than it is at present; this is evident from the occurrence of a series of parallel terraces, plainly traceable on each side of the valley. In addition to these lakes, numerous alkaline lagunes and boiling springs are met with throughout this region.

The *Artemia fertilis*, before referred to as being plentiful in Mono Lake, is also exceedingly abundant in Owen's Lake. A peculiarity of this crustacean is that it congregates into masses which have often a strange appearance in the water. These masses sometimes stretch out in such a way as to have the form of a serpent, while at others they represent circles or various irregular figures. A gentle breeze scarcely affects water filled by *Artemiæ*, so that while on all sides the water is slightly ruffled, that which is occupied by these dense aggregations remains perfectly smooth, thus indicating the figure of the mass. On placing some of these crustaceans in a bottle filled with lake water, for the purpose of preserving them for subsequent microscopical examination, it was found that those which died rapidly disappeared, and on closely examining what had taken place, it soon became evident that as soon as vitality had ceased, chemical action was set up, and the animal gradually dissolved in the strongly alkaline brine.

Burton Springs are situated at the extreme northern point of Owen's Valley. These springs rise from the earth over an area of about eighty square feet, which forms a basin or pond that pours its heated waters into a narrow creek. In this basin a vegetable growth is developed at a temperature of about 160° F., and is continued into the creek to a distance of about a hundred yards from the springs; where, at a temperature of about 120° F., the algæ grow to a length of over two feet, looking like bunches of waving hair of a beautiful green colour. Below the temperature of 100° F., these plants cease to grow, and give way to a slimy fungus, which is also green in colour, but finally disappears, as the temperature of the water decreases. Dr. J. H. Wood, junr., who has carefully examined this growth, makes the following observations with regard to it:—"This plant certainly belongs to the *Nostochaceæ*, and seems a sort of connecting link between the genera *Hormosiphon* of Kützing and *Nostoc*.

"The best algologists now refuse to recognize the former group as generically distinct, and the characters presented by this plant seem to corroborate this view.

"The species appears to be an undescribed one, and I would propose for it the specific name *Caladarium*, which is suggested by its place of growth."*

Twenty miles south from Owen's Lake, across a sage-brush and grease-wood waste, the surface of which is plentifully strewn with fragments of lava, pumice and basalt, is Little Lake. This sheet of water, which is of comparatively small extent, is surrounded by huge masses of contorted vesicular lava, and

* "Silliman's Journal," vol. xlvi. 1868, p. 33.

evidently occupies the cavity of an ancient volcanic vent. The waters of this lake are considerably less alkaline than those of Owen's Lake, but bubbles of carbonic acid make their way to its surface in almost uninterrupted streams.

Fifteen miles east from this point are numerous hot springs; the path for the greater portion of this distance lies over lava-flows, which render travelling slow and fatiguing. At the principal group of springs the ground is covered, over a large extent, by innumerable cones of plastic mud, varying in height from a few inches to several feet; these rise above the surface of a seething swamp, and give issue to steam and jets of boiling water. In some cases the steam and gases, instead of issuing from cones as above described, are evolved under the surface of water and mud contained in basin-shaped reservoirs formed in the decomposed rock. By these means are produced multitudes of boiling cauldrons in which violent ebullition keeps clay in a constant state of suspension; this clay varies in colour from bluish grey to bright red. The waters of these springs are much employed by the Indians as an embrocation for the cure of diseases of the eye; on examination they were found to contain 48 grains of solid matter to the gallon, of which amount 26 grains are sulphate of aluminium; in addition they contain lime, soda, potash, and a little free sulphuric acid.

Borates of sodium and calcium occur in various localities in North America. The two borax lakes are both situated near the shores of Clear Lake in Lake County, California, seventy miles north-west of the port of Suscol, and one hundred and ten from the city of San Francisco.

The larger of these lakes is separated from Clear Lake by a low ridge of volcanic materials loosely packed together, and consisting of scoriæ, obsidian, and pumice; it has an average area of about three hundred acres. Its extent however varies considerably at different periods of the year, as its waters cover a larger area in spring than during the autumnal months. No stream flows into its basin, which derives its supply of water partly from drainage from the surrounding hills, and partly from subterranean springs discharging themselves into the bottom of the lake. In ordinary seasons its depth thus varies from five feet in the month of April to two feet at the end of October.

The borax occurs in the form of crystals of various dimensions imbedded in the mud of the bottom, which is found to be most productive to a depth of about three and a-half feet, although a bore-hole which was sunk near its centre to the depth of sixty feet afforded a certain amount of the salt throughout its whole extent.

The crystals thus occurring are most abundant near the centre

of the lake, and extend over an area equivalent to one-third of its surface; they are, however, also met with in smaller quantities in the muddy deposit of other portions of the basin. The largest crystals, some of which are considerably above a pound in weight, are generally enclosed in a stiff blue clay, at a depth of between three and four feet; and a short distance above them is a nearly pure stratum, from two to three inches in thickness, of smaller ones; in addition to which crystals of various sizes are disseminated through the blue clayey deposit of which the bottom consists.

Besides the borax thus existing in a crystallized form, the mud itself is highly charged with that salt, and, according to an analysis by Dr. Oxland, affords, when dried, in those portions of the lake which have been worked (including the enclosed crystals), 17·73 per cent. Another analysis of an average sample, by Mr. G. E. Moore, of San Francisco, yielded 18·86 per cent. of crystallized borax. In addition to this the deposit at the bottom of the other portions of the basin, although less productive, still contains a large amount of borax.

Water collected from Borax Lake, in September, 1863, was found by Mr. Moore to contain 2401·56 grains of solid matter to the gallon, of which about one-half was common salt, one quarter carbonate of sodium, and the remainder chiefly anhydrous borax, equal to 535·08 grains of crystallized salt to the gallon. Traces of iodine and bromine were also detected. A sample of water taken from the interior of a coffer-dam sunk in the middle of the lake, and which had been allowed to fill by percolation from the bottom upwards, was found to be more concentrated, yielding 3573·46 grains of solid matter to the gallon, but it contained the same ingredients, and in nearly the same proportions, as the water from the lake itself. When evaporated to dryness, this water yields a considerable quantity of finely divided carbon, resulting from the various organic bodies which have been dissolved in it.

Mud from the bottom of Borax Lake is in high repute among the local Indians as an *insecticide*, and is used in the following way. The head of the patient is thickly plastered with mud, which is well rubbed in, and then allowed to become perfectly dry; when dry, it is removed by rubbing between the hands, and with it disappears the colony of parasites. Ordinary clay is, under pressure of circumstances, sometimes employed for this process of shampooing, but when alkaline or boracic mud is available, it is considered more efficacious.

When this locality was visited by me in 1866, borax was manufactured exclusively from the native crystals of crude salt, while the mud in which they were found was returned to the lake after a mechanical separation of the crystals by washing. The extrac-

tion of boracic mud was effected by the aid of sheet-iron coffer-dams. The only apparatus employed consisted of a raft, covered by a shingled roof, provided with an aperture in its centre about fifteen feet square, above which were hung, by suitable tackle, four coffer-dams, each six feet square in horizontal section, and nine feet in depth. This raft, or barge, was successively moored in parallel lines across the surface of the lake, and at each station the four dams were sunk simultaneously by their own weight into the mud forming the bottom.

When they had thus become well imbedded, the water was baled out, and the mud and crystals removed, by means of buckets, into rectangular washing-vats, into which a continuous stream of water was introduced from the lake by Chinese pumps, the contents being at the same time constantly agitated by the aid of wooden rakes. In this way the muddy water continually flowed off, finally leaving a certain amount of crude borax at the bottom of each tank; this was purified by re-crystallization. From the density acquired by the 70,000 gallons of water daily employed for this purpose, it is evident that only about one-half of the borax existing in the form of crystals was thus obtained, while the mud was again returned to the lake.

Instead of the coffer-dams, a small hand-dredging machine, worked, like the former, by Chinese labour, was subsequently introduced; but the mud brought up by it was subjected to the wasteful process of washing before described.

The crystals of crude borax thus daily obtained amounted to about 3,000 lbs.; these were dissolved in boiling water, and re-crystallized in large lead-lined vessels, from which the purified salt was removed to be packed into boxes, each containing 114 lbs., in which it was forwarded to San Francisco. The loss of weight experienced in the process of purification amounted to about 13 per cent.

Shortly after my visit in 1866, the manufacture of refined borax at "Big Borax Lake" was suspended, and I am not aware whether it has now been resumed, but the works do not appear to have been in operation in 1874.

Little Borax Lake covers an area of about thirty acres, and is usually dry during the months of September and October; it is then covered by a white crust, which is collected by Chinese labourers, and carried to the works, where it is refined by re-crystallization. *Ulexite*, a double borate of sodium and calcium, is brought to this place from Wadsworth, in the State of Nevada—a great distance, with several transhipments—to be treated at these works; it appears that on account of the presence of carbonate of sodium, and the cheapness of fuel, this can be done more cheaply here than in Nevada.

Clear Lake is a large and picturesque sheet of water, twenty-

five miles long, by about seven wide, surrounded by mountains, which in many places rise abruptly from the water's edge. Boat-life on this lake is delightful; the water is smooth, there is usually a sufficient breeze for sailing, and should it fall calm, an Indian can always be hired to row.

Lying about a mile beyond the ridge which borders Borax Lake on the north-east, and at the foot of a shorter arm of Clear Lake, which extends off to the southward parallel with the larger one, is an interesting locality, known as the "Sulphur Bank." It is some six or seven acres in extent, and consists of a much decomposed volcanic rock traversed by innumerable fissures, which has become almost covered by a large accumulation of sulphur.

From the fissures steam and gas are constantly issuing, and over and through the mass large quantities of sulphur have been deposited in such a way that at a short distance the whole bank appears to consist of this substance. Into some of these cavities a pole may be inserted for a distance of several feet, and they are often lined with stalactites and beautiful crystallizations of sulphur.

Sulphur is being constantly deposited, and its deposition is attended by the evolution of carbonic and boric acids. The gaseous matters issuing from these crevices appear to be the agency by which the various substances now deposited in the cavities have been brought to the surface. Sulphur is deposited on the sides of the various fissures either in the form of crystals, or as amorphous translucent masses of a beautiful yellow colour. It is sometimes intermixed with cinnabar, the presence of which was first discovered by Dr. Oxland; but more frequently with minute cubical crystals of iron pyrites. Pulverulent silica, blackened by some hydrocarbon resembling coal-tar, is also frequently observed.

On the sides of the cavities colloid silica is found coating chalcedony and opalescent quartz in the various stages of formation, from the gelatinous state to that of the hardest opal. The indurated material is sometimes colourless, but is more frequently permeated by cinnabar and iron pyrites, or blackened by the tarry matter before referred to. Cinnabar is also found in laminæ, and occasionally even in veins and concretionary masses of considerable thickness.

In addition to being employed as a source of sulphur, this deposit has been worked for quicksilver, and has produced large quantities of that valuable metal.

On the shore of Clear Lake, near the sulphur bank, is a hot spring, of which the outlets, even when the water is low, are partially beneath the lake, so that the amount flowing from it cannot be ascertained. Hot water, however, rises through the

sand at various points extending over a considerable area. A specimen of water collected by Mr. Moore from this spring was found by him to contain 184·62 grains of common salt, 76·96 grains of bicarbonate of sodium, 36·37 grains of free carbonic anhydride, 103·29 grains of borax, and 107·76 grains of bicarbonate of ammonium, in an imperial gallon; besides silica, alumina, and traces of various other substances.

Professor Whitney remarks with regard to this spring:—"The most extraordinary feature in the above analysis is the very large amount of ammoniacal salts shown to be present in this water, in this respect exceeding any natural spring-water which has ever been analysed. Mr. Moore thinks that, as in the case of the boracic acid waters of Tuscany, this ammoniacal salt may be separated and made available for economical purposes. This locality is worthy of a most careful examination, to ascertain how considerable a flow of water can be depended on." *

Dr. A. Blatchly, of San Francisco, in speaking of the Geyser group of quicksilver mines, says:—"Nearly all these veins contain iron in considerable amounts, frequently in sufficient quantities to constitute an ore of iron. Gold, silver, and copper are also frequently constituents of these lodes, and occasionally chrome iron in considerable quantities. But, so far as is known, in no instance have the precious metals been sufficiently abundant to pay for the expense of extraction.

"Bitumen is found in nearly all these veins, sometimes a deposit of a gallon or two in one cavity.

"Thermal springs are numerous throughout the whole quicksilver-region, and the uniformity of their occurrence leads prospecters to the belief that there is an intimate relation between the causes which generate thermal springs, and produce deposits of cinnabar, and that where one is found the other may probably occur in the vicinity." †

On the eastern slope of the Sierra Nevada, near Walker's Pass, borax is found in what appears to be the bed of an ancient lake, large crystals of this substance having been met with in a hardened mud, exactly resembling those found in the blue clay of Borax Lake. By far the largest amount of borax is, however, obtained from the indurated mud, where it exists in common with other salts. This mud, from which borax is separated by lixiviation, contains about half its weight of that salt, and is a light clay-like body, having a strongly saline and alkaline taste. The portion insoluble in water effervesces on

* "Geological Survey of California," p. 100.

† "Mineral Resources West of the Rocky Mountains," 1875, p. 176. Raymond.

being attacked by hydrochloric acid, and contains silica, alumina, lime, ferrous oxide, and magnesia. Similar deposits containing borax exist in Panamit and Death's Valley, in Lower Nevada; but these desolate districts have not as yet received so careful an examination as they deserve.

About twenty miles west of San Bernardino is the so-called "Cane Spring District," where ulexite or boronatrocalcite is found, over an area about ten miles in width by fifteen in length. The surface of the ground is covered by efflorescent salts, commonly known as "alkali," beneath which the borax salts (chiefly ulexite) are found at a depth of only a few inches.

At Hot Springs, in the north-western portion of the State of Nevada, at a height of 4,500 ft. above the level of the sea, and where the water issuing from the ground has a temperature of about 190° Fah., there are deposits of boronatrocalcite, extending over considerable areas. Here, as far as the eye can reach, nothing is seen but barren mountains, formed of a black porous lava; while the valleys are covered by an efflorescence of a mixture of common salt and sulphate and carbonate of sodium. In other cases the sands of these mountain valleys contain deposits of more or less pure boronatrocalcite.

Geysers and hot springs are numerous in the whole of this district, and from the number of extinct geyser vents still visible, they were, probably, at one time much more numerous than at present.

The analysis of an average sample of the boracic material from Nevada afforded Mr. Loew the following results:—

Boronatrocalcite	22·13
Chloride of sodium	2·80
Sulphate of sodium	2·62
Sulphate of calcium	6·17
Carbonate of calcium	3·01
Carbonate of magnesium	·79
Clay	19·70
Quartzose sand	26·03
Water	15·04
Traces of potash, iodine, and loss . .	1·71
	100·00 *

The purification of crude borax (*tincal*) is effected by a simple re-crystallization, but the preparation of marketable borax from boronatrocalcite is attended with considerable difficulty, more particularly as the appliances available in the remote deserts in which it occurs are of the most primitive and limited description.

* "Moniteur Scientifique," 1876, p. 1230.

When boronatrocalcite is moderately pure, it is first ground and subsequently dissolved in water, with the addition of an amount of carbonate of sodium sufficient to effect the decomposition of the calcic carbonate present.

The solution is subsequently heated, and the carbonate of calcium allowed to subside, when the liquor is drawn off, and, after concentration, borax is obtained by crystallization.

Unfortunately, this mineral often contains notable quantities of gypsum, which transforms an equivalent amount of carbonate of sodium into Glauber salt, a relatively valueless product. This salt is also frequently present in the material operated upon, and thus materially adds to the difficulty of treatment. In order to avoid these difficulties, it has been proposed to treat native boronatrocalcite with sufficient sulphuric acid to transform the whole of the carbonate of calcium into gypsum, and to liberate boric acid, to be subsequently saturated by carbonate of sodium. Boronatrocalcite has also been treated with excess of hydrochloric acid, in order to obtain crystallized boric acid, but neither of these processes has hitherto afforded satisfactory commercial results.

The comparatively recent discovery of large quantities of this substance in Nevada will, no doubt, eventually to some extent, affect the Tuscan producers of boric acid; but the fact that crude boronatrocalcite varies considerably in its composition, and that it is found in situations in which its local treatment would be almost impossible, has hitherto prevented this mineral from being extensively employed as a source of commercial borax.

CAN WEATHER BE PREDICTED IN THE BRITISH ISLES?

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SOME of our readers may have heard of Arago's famous saying, in the "Annuaire of the Bureau des Longitudes" for 1846, "Jamais, quels que puissent être les progrès des sciences, les savants de bonne foi et soucieux de leur réputation ne se hasarderont à prédire le temps," and yet, within fifteen years after that dictum was published, a regular service of storm warnings had been organized in England, France, and Holland; and now, at the expiration of thirty years, we could name more than one "savant de bonne foi et soucieux de son réputation" who considers the prediction of weather to be a subject of investigation which promises reasonably satisfactory results.

When we speak of the prediction of weather, however, we refer more particularly to the prediction of storms or of transient disturbances of the atmosphere; for if we come to consider the problem of really foretelling weather for the practical purposes of the farmer—of informing him, months beforehand, what crops he may put into the ground with a reasonable prospect of a paying return, or even days beforehand, when he may cut his hay or reap his corn with a fair probability of saving it without rain, we must admit that we have not made one step in advance of the position laid down for us by Arago thirty years ago. What is our most recent experience? A rainfall in the month of December of 5·82 inches in London, being three times the average fall in the month for the last sixty years, and exceeding by 16 per cent. the very heaviest fall in December during that period. To go a little further back, the year 1872, in its widespread and persistent rainfall, was almost unparalleled since accurate measurements have been kept; the total excess over the United Kingdom amounting to 36 per cent. of the annual fall, and surely we might have expected that some years' respite from the plague of waters was due to us,—but what have been the real facts? Only three years later, in the autumn of 1875, the damage caused by successive floods exceeded anything that modern records showed; and a short fifteen months later, in the

past winter, the whole of the low-lying lands of England have been submerged. Now, in March, the railway trains have just ceased carrying boats on some lines; and in Scotland we hear of thousands of acres of the richest land lying fallow for the year owing to the utter impossibility of working the soil in its present water-logged condition.

Articles in the papers may repeat *ad nauseam* that engineers are to blame for this state of things, and there can be no doubt that much more might have been done to regulate the water supply of the country than has yet been effected; but, on the other hand, engineers may fairly retort "Forewarned would be forearmed," and ask why meteorologists did not give them some hint of the deluges which were impending.

Meldrum and others have of late devoted much attention to the investigation of a supposed periodicity of rain according with that of sunspot frequency, with some measure of success, but no one yet has, in his wildest dreams, imagined that he could forecast the amount of rainfall for a given district in England at the epoch of the next sunspot maximum.

Talking about floods, however, there is one matter which deserves most serious consideration, and is far from encouraging for our future prospects. This is that, as a result of civilization, floods are increasing in their intensity, the rainfall being supposed to be unchanged in amount. This appears most unmistakably from the reasoning of M. Wex, the well-known hydraulic engineer of Vienna, and he is supported by other authorities. Rivers such as the Danube or Volga are gradually, but surely, becoming less and less navigable in the upper part of their course, while the floods in the lower part are becoming more and more disastrous. The reason of this is that the reckless clearing of forest land has altered the whole condition of the water flow of the country. The land, bared of its forest, can no longer retain the rain water which falls on it, and yield it slowly for the supply of springs. The rain pours in torrents down the hill sides, sweeping before it soil, gravel, and boulders, which it deposits in the calmer waters of the river bed, creating shoals unknown in more fortunate times; while, at the same time, this rapid discharge of the water from the surface causes a delivery within a few days which would have taken weeks or months to complete itself under more primitive conditions. The water which should have lain in the ground as provision against the summer drought is discharged at once, to the immediate detriment of the lower country inundated by the rapid rise of the river, and to the prospective loss of the upper country, owing to the deficiency of water for navigation, or for the purposes of agricultural irrigation.

In this country our forests disappeared long enough ago, but

overdraining exerts a similarly pernicious effect to the clearing of woodland. The upper proprietors demand that the land shall be drained as perfectly as possible. Thereby the water which should have lain in the soil for months escapes at once, and causes the river level to rise at the lower part of its course, washing the unlucky residents on its banks out of house and home.

This is, however, a digression, and as to the prediction of weather we may say that it has not at the present time been shown to be feasible to forecast weather for one short week, except on the principle, which affords us scanty consolation, that weather, when once well established, takes a long time to change. This comes out very clearly from the researches of M. Köppen, at present engaged at the Deutsche Seewarte at Hamburg. He has shown in a paper in vol. ii. of the "Russian Repertorium für Meteorologie" that if we investigate weather changes by the laws of probability we find that, as regards temperature, if a cold five-day period sets in after warm weather we may bet two to one that the next period will be cold too; but if the cold has lasted for two months, we may bet nearly eight to one that the first five days of the ensuing month will be cold likewise. This does not mean that the chances are in favour of the weather never changing, but are only against its changing on a definite day, and increase with the length of time the existing weather has lasted. The problem is somewhat similar to that of human life: the chance of a baby a year old living another year is less than that of a man of thirty living to be thirty-one.

There is one very interesting idea which, if it could be worked out, would be of great value to us, and that is that we could foresee the coming of such a winter as we have just passed through if we had regular and early information as to the state of sea temperature off the coast of Portugal during the late autumn. Franklin, in 1776, traced the Gulf Stream right across the Atlantic in November, and found a temperature as much as 5°·5 above the mean for the month at one spot in about 10° W. and 45° N. Now in January 1822, H.M.S. *Iphigenia*, nearly on the same spot, found a temperature 3°·2 above the average in 44° 30′ N.; the difference increased to 6° in 39° N., and again diminished to 4° in 32° 20′ N., while at the same period the general temperature in the adjoining parallels, both to the northward and the southward, even as far as the Cape Verde Islands in 19° 40′, was colder by a degree and upwards than the usual average. We quote from Sabine's "Pendulum and other Experiments," p. 430. The same writer goes on to say: "Nor is the probable meteorological influence undeserving of attention of so considerable an increase in the temperature of the surface

water over an extent of ocean exceeding 600 miles in latitude and 1,000 in longitude, situated so importantly in relation to the western parts of Europe. It is at least a remarkable coincidence that in November and December 1821, and in January 1822, the state of the weather was so unusual in the southern parts of Great Britain and in France as to have excited general observation. In the meteorological journals of the period it is characterised as 'most extraordinarily hot, damp, stormy, and oppressive;' it is stated that 'an unusual quantity of rain fell both in November and December, but particularly in the latter;' that 'the gales from the W. and SW. were almost without intermission,' and that in December the mercury in the barometer was lower than it had been known for thirty-five years before."

Now if we compare these statements with our experience of the winter we have just come through we shall find that the principal features in 1821-2 to which Sir E. Sabine refers were manifested in an exaggerated degree in 1876-7. We are told by Prof. Daniell that the mean pressure of December 1821 was considerably below the mean. 29·467 in. is given as the value, but it does not appear whether these figures are reduced to sea level or not. Now the mean pressure of last December was 29·486, being nearly half an inch lower than its average figure for the month, 29·943 ins., as given by Buchan for eighty-nine years' observations. The extraordinary low reading in 1821 was 28·12 ins. December 24; and we had 28·33 at 11 a.m. December 4, 1876.

As regards the rainfall, the subjoined figures will show how much worse off we are now than our fathers were in 1822. The actual figures for London for the respective periods are—

	1821 2.	1876-7.	Average of 60 years. 1813-72.
November . .	4·42 ins.	2·63 ins.	2·28 ins.
December . .	4·82 „	5·82 „	1·93 „
January . . .	0·64 „	4·69 „	1·91 „
February . . .	0·98 „	1·73 „	1·50 „
Total for four months	10·86 ins.	14·87 ins.	7·62 ins.

We have, therefore, had nearly double our average quantity as given by Mr. Dines, and four inches more than fell at the same period fifty-five years ago, and attracted so much attention then. As regards extraordinarily high temperatures and successive prevalence of storms, we need hardly say that Sir E. Sabine's description falls short of our recent experience.

Now let us see what tale we have to tell of sea temperature in the autumn to compare with the experiences of Franklin and of Sabine. It is too early yet for us to have received all our information for so recent a date, as the logs of outwa d bound

ships will not reach the Meteorological Office for months to come, but thus much may be said:—Two experienced captains, who have been traversing the part of the Atlantic in question for several years back, have independently informed me that they never recollect to have met with so high a temperature of the sea water in the neighbourhood of the Azores in November as they observed last autumn. As to actual observations, Captain R. D. Lunham, a most trustworthy observer, reports 60° on November 1, nearly on the very spot where Franklin had 61° just 100 years ago.

This instance would, therefore, appear to confirm Sabine's theory. He goes on to say: "There can be little hesitation in attributing the unusual extension of the stream in particular years to its greater initial velocity, occasioned by a more than ordinary difference in the levels of the Gulf of Mexico and of the Atlantic. It has been computed by Major Rennell, from the known velocity of the stream at various points of its course, that in the summer months, when its rapidity is greatest, the water requires about eleven weeks to run from the outlet of the Gulf of Mexico to the Azores, being about 3,000 geographical miles; and he has further supposed, in the case of the water of which the temperature was examined by Dr. Franklin, that perhaps not less than three months were occupied in addition by its passage to the coasts of Europe, being altogether a course exceeding 4,000 geographical miles. On this supposition the water of the latter end of November 1776 may have quitted the Gulf of Mexico, with a temperature of 83°, in June, and that of January 1822 towards the end of July with nearly the same temperature. The summer months, particularly July and August, are those of the greatest initial velocity of the stream, because it is the period when the level of the Caribbean Sea and the Gulf of Mexico is most deranged. If the explanation of the apparently very unusual facts observed by Dr. Franklin in 1776 and by the *Iphigenia* in 1822 be correct, how highly curious is the connection thus traced between a more than ordinary strength of the winds within the tropics in summer, occasioning the derangement of the level of the Mexican and Caribbean Seas, and the high temperature of the sea between the British Channel and Madeira in the following winter."

It need not be remarked that it will be a matter of the highest interest and importance if we can, by observations taken on the Equator months before, draw conclusions as to the character of our coming seasons. If this should turn out to be true, we should have traced the history of our weather a few steps further back, but should not even then have discovered the absolute causes to which its changes are to be ascribed. We

should simp'y be gaining early information, without prophesying at all.

In this connection I may mention, without in any way pledging myself to its correctness, an opinion which has repeatedly been stated, and of late has been cited by one of the ablest scientific men in Australia, that the weather of those colonies appears, as he says, to follow in the wake of European weather: that a wet winter here means a wet winter for them during our summer. This seems to be rather inexplicable unless on the hypothesis that other influences are at work, independently of the earth's motion in her orbit; but even then there seems to be *primâ facie* no reason for thinking that the southern hemisphere should generally follow the northern instead of preceding it.

So much, then, for forecasting weather on a grand scale; and we must say that from one point of view it is fortunate that nothing of the kind has yet been attempted. If we were able now to furnish any grounds for an estimate of the probable yield of the chief corn-producing countries at the coming harvest, the lives of meteorologists would be a burden to them from the constant applications to them from corn merchants and others as to their prospects of successful speculation. I do not for one moment mean to say that it may not be possible, say in India, to form highly valuable predictions of the probable character of a coming season, and so to anticipate famine; but in this changeable climate any idea of the kind is utterly Utopian in 1877.

Let us now turn to the subject of what are ordinarily termed weather forecasts, the practical manifestation of which is the issue of storm warnings to seamen and farmers.

When Le Verrier proposed to Sir G. Airy an international system of storm warnings, he used, in a letter dated April 4, 1860, the following words:—

"Signaler un ouragan dès qu'il apparaîtra en un point de l'Europe, le suivre dans sa marche au moyen du télégraphe, et informer en temps utile les côtes qu'il pourra visiter, tel devra être le dernier résultat de l'organisation que nous poursuivons."

This is a far more modest prospectus than that of the unofficial weather prophets of the present day, who announce for days beforehand the changes which are about to supervene, and even in some cases the precise number of hours of fine weather which may be expected on the day following their prophecy.

Admiral Fitz-Roy also was not content with Le Verrier's programme, but announced his readiness to forecast the weather for three days in advance. A signal hoisted by his orders indicated a probability of a gale occurring within the next three days at the actual part where it was hoisted. Accordingly

when the results of his system are compared with those obtained at the present day, the fact of the utter dissimilarity of the two methods of warning is entirely ignored. At the present time the signals only cover the period of forty-eight hours, but they are held to be justified by the occurrence of a storm anywhere in the neighbourhood of the place where they are exhibited. It is therefore clear that the two systems are not, in the slightest degree, intercomparable.

If we look at our present position as regards storm warnings, and compare it with Le Verrier's proposal of sixteen years ago, we see that that still describes very fairly the extent of our weather knowledge.

When we see that a disturbance of the atmosphere actually exists, we can issue intelligence of the fact to the districts likely to be affected by it, and the value of such warnings depends on the correctness of the ideas formed by us as to the character and extent of the disturbance itself—by this is meant particularly the point or points whence the wind will blow, the force which it will exert, and the area it will cover—the direction of its advance, and the rate of its motion.

On all these points there prevails as yet a great amount of uncertainty; but that, on the whole, a satisfactory result of the system is achieved appears from the fact that a total percentage of success of warnings of strong winds exceeding 75 has been maintained for the last four years, while of actual severe gales following warnings the percentage is as much as 44.

It therefore appears that warnings are more astray on the ground of over-precaution than of negligence; but yet it would be absurd to deny that in almost every year some of our very severest gales have come on us suddenly and swept much of the coasts before any warning has been issued.

This is mainly owing to the fact that the funds available for the purpose will not allow of sufficiently frequent communication between the outposts and head-quarters, and that much time is always lost in the necessary telegraphing to and fro.

It has repeatedly been urged on us that we should institute a regular service of telegrams from America, but we had for some years such a service with Newfoundland, and derived little benefit from it. What would really be of value to us would be that a thoroughly competent meteorologist on that side should telegraph daily a general *résumé* of the weather prevailing on the Atlantic seaboard of the States, with intelligence of any disturbances leaving them which showed signs of an intention to cross the herring-pond. This has been attempted of late, with some measure of success, by the "New York Herald," which prophesied a storm on our coasts for

February 19, a prediction which was amply fulfilled, but not at all in the way at first anticipated by those who read the telegram here, for the gale was from the northward, while the wording of the message would have led us to anticipate a southerly gale.

Since that date several other telegrams have been received which have, for the most part, met with fulfilment in a greater or less degree, but have all possessed the same capital defect for practical purposes, that they have been too vague as to date, and have given no hints as to the direction whence the gale would blow.

Both of these are most important particulars; as to the direction of the gale, a doubt on this head may make all the difference in deciding whether or not such an anchorage will be safe; as regards precise time, a warning hoisted too soon may make a coaster miss his chance of a short run, or cause a fisherman to lose his night's earning. In either case the system falls into discredit, and the warning is disregarded when next hoisted; "Wolf! wolf!" having been cried too often.

The non-seafaring public have very little notion of the different lights in which warnings are regarded in seaport towns and among ordinary landsmen. In some ports which could be named the system is not in operation because the authorities think the signals would frighten the fishermen. At one place the flymen of the town succeeded in putting down the warning system, because none of the visitors would take a drive while the signal was flying; and lastly, at all places the interest of the shipowner, and to some extent of the captain, is against the warnings, for the fact of the exhibition of the signal is sufficient to make the sailor plead stress of weather, and betake himself to the public-house bar.

It appears therefore that it is not a simple question of announcing to every port in the kingdom the weather which is coming; but yet, through evil report and good report, the system established by Admiral Fitzroy has made good its footing, and is steadily growing in popularity and usefulness.

We have mentioned warnings for agricultural purposes, but our space will not allow of our treating this question at any length. They are in full operation in the United States, but there the area covered by the telegraphic system is so much larger than in Western Europe—irrespective of the fact of the system being military, and provided on a most liberal scale with funds—that the results attainable there furnish no precedent for us.

Warnings of this nature were organized in France last year, but we have not as yet seen any results of the system. The great difficulty here is to insure that the message comes to the

knowledge of the farmer. As the cost will not allow of the mountain, or the telegram, going to each individual Mahomet, it only remains for Mahomet to go to the mountain, or the nearest telegraph office, every day, and "govern himself accordingly," to use Mr. Ayrton's phrase. The question in such a case is, Is the play worth the candle in our uncertain climate?

REVIEWS.

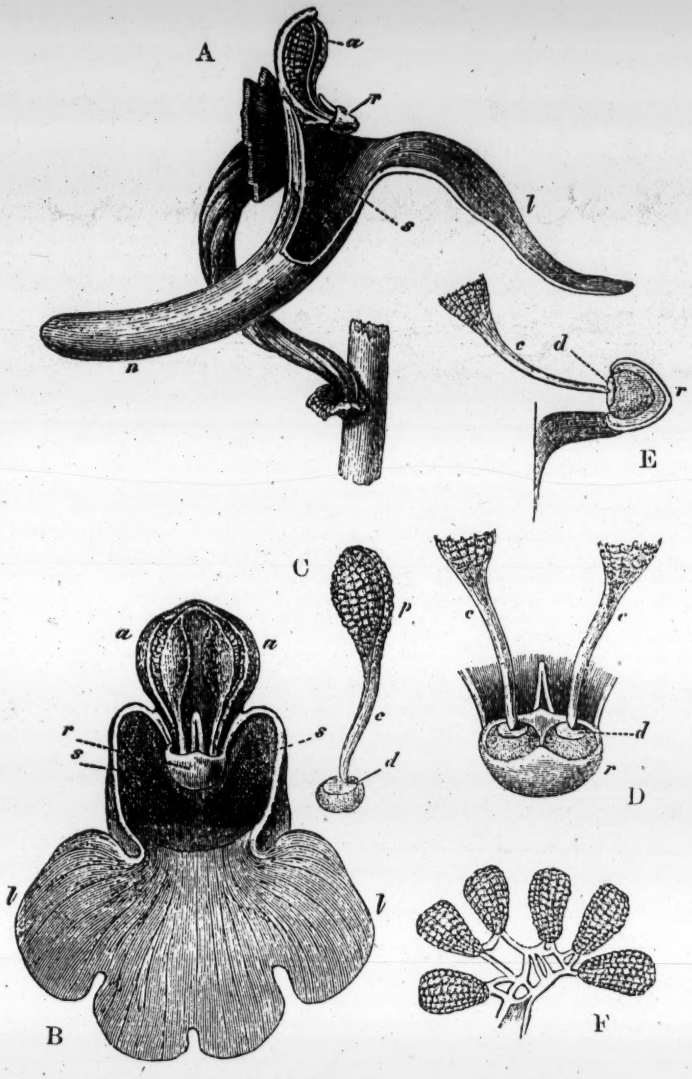
THE FERTILIZATION OF ORCHIDS.*

AMONG the points raised by Mr. Darwin in his celebrated work "On the Origin of Species" was the doctrine of the necessity of frequent or occasional cross-fertilization in the case even of plants whose flowers contain both stamens and pistils within the same set of envelopes. Several interesting cases in illustration of this principle were subsequently brought forward by Mr. Darwin himself; and in our last number we called attention to the publication by him of a most important series of observations in which the beneficial effects of such intercrossing, usually effected in nature by insects, were demonstrated beyond a doubt; but the first independent work in which the subject was treated by Mr. Darwin, was his treatise on the fertilization of orchids published in 1862, a second edition of which, embracing the later researches of the author, and the results obtained by many other observers, has lately appeared. Although this is only a second edition, the interest attaching to the subject, and the length of time that has elapsed since the appearance of the first edition, induce us to give a somewhat lengthened notice of it.

Whilst there was much *à priori* probability in the assumption that the occasional cross-fertilization of hermaphrodite flowers was a law of nature, a probability which received strong support from the observations of Mr. Darwin and others upon various plants, and the part played in the process by insects was not very doubtful, seeing that in most cases the influence of the wind could hardly be involved, and it is a matter of daily experience that flower-haunting insects are constantly dusted with pollen which they must necessarily convey from one flower to another, it was still a matter of considerable interest to find some plants in which this method of fecundation was a demonstrable necessity. Curiously enough the absolute evidence required was first obtained by the study of a group of plants in which the flowers are so singularly constructed that the stamens and pistils appear to form a single organ, and in which therefore the conditions for self-impregnation might at the first glance be supposed to be especially secured. In the orchids, in fact, the two cells of the usually single anther are imbedded in a portion of the pistil which stands up above the effective stigma, the whole

* "The Various Contrivances by which Orchids are fertilised by Insects." By Charles Darwin, M.A., F.R.S. A Second Edition, revised. Sm. 8vo. London: John Murray. 1877.

Fig. 1.



STRUCTURE OF THE FLOWER IN ORCHIS MASCULA.

The small letters throughout indicate the same parts, viz.—*a*, anther; *r*, rostellum; *s*, stigma; *l*, labellum; *n*, nectary; *p*, pollinium or pollen-mass; *c*, caudicle of pollinium; *d*, viscid disc of pollinium.

A. Side view of flower, with all the petals and sepals cut off except the labellum, of which the near half is cut away, as well as the upper portion of the near side of the nectary.

B. Front view of flower, with all the sepals and petals removed, except the labellum.

C. A single pollinium or pollen-mass, showing the packets of pollen grains (*p*), the caudicle (*c*), and viscid disc (*d*).

D. Front view of the discs and caudicles of both pollinia within the rostellum, with its lip depressed.

E. Section through one side of the rostellum in a direction from front to back of the flower, with the included disc and the caudicle of one pollinium.

F. Packets of pollen-grains, bound together by elastic threads, which are here shown as stretched.

*** For the use of these and the following illustrations we are indebted to the kindness of Mr. John Murray.

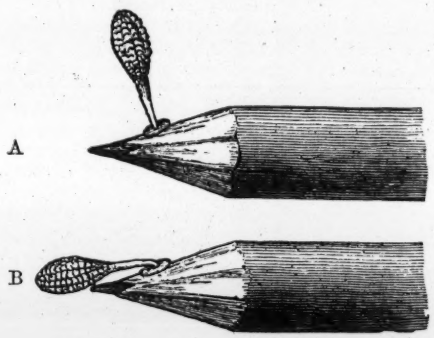
forming a body which received from the older botanists the name of the "column," and although, in some cases, these flowers are self-impregnating, fertilization is always effected by the escape of the contents of the anther cells from the cavities in which they were imbedded, before their contact with the stigmatic surface. This, indeed, was understood by Sprengel and some other old botanists, but it was reserved for Mr. Darwin to demonstrate clearly the process by which the fecundation is performed. The description of what takes place in the common orchis (*Orchis mascula*) will serve to explain the general nature of these curious phenomena.

In *Orchis mascula*, the well-known Purple Orchis of our meadows, the stigma is a bilobed viscid surface situated on the front of the pistil (*s*, in fig. 1), immediately beneath a projecting, pouch-like process (*r*) called the "rostellum," above which is the anther (*a*) consisting of two separate cells, each containing a coherent mass (*p*) of pollen, or "pollinium." The pollinia, which, when mature, are exposed by a longitudinal slit in the cells containing them, are composed of a number of wedge-shaped packets of pollen-grains, united by exceedingly elastic, thin threads (see fig. 1, F), which combine towards the lower part of each pollinium, to form a straight elastic stalk (*c*), the "caudicle." The lower extremity of each caudicle is attached to a small disc of membrane (*d*) forming part of the superior and posterior covering of the rostellum. The latter is a nearly spherical projection, which, at an early period of its growth, consists of a mass of polygonal cells, which soon become converted into two balls of extremely viscid, semi-fluid matter, destitute of all structure, lying quite freely within the rostellum, except at the back, where each of them adheres to one of the small, membranous discs (*d*), already mentioned as having the caudicles of the pollinia attached to them on their upper surface. These discs are at first continuous with the rest of the membrane enclosing the rostellum, but the slightest touch suffices to cause this membrane to split in certain definite lines, when, if the membrane of the front of the rostellum is pushed down, the two viscid balls which it enclosed are at once exposed.

This is the mechanism; its mode of action is as follows:—"Suppose an insect," says Mr. Darwin, "to alight on the labellum, which forms a good landing place, and to push its head into the chamber at the back of which lies the stigma, in order to reach with its proboscis the end of the nectary. Owing to the pouch-formed rostellum projecting into the gangway of the nectary, it is scarcely possible that any object can be pushed into it without the rostellum being touched. The exterior membrane of the rostellum then ruptures in the proper lines, and the lip or pouch is easily depressed. When this is effected, one or both of the viscid balls will almost infallibly touch the intruding body. So viscid are these balls that whatever they touch they firmly stick to. Moreover the viscid matter has the peculiar chemical quality of setting, hard and dry, in a few minutes' time." The same effects may be produced by pushing the pointed end of a pencil in the direction of the nectary; the viscid balls immediately adhere to it, and as the anther-cells are already open in front, the withdrawal of the pencil or of the insect's head, at once removes one or both of the pollinia, which may be pulled out, firmly cemented to the object and sticking up from it like horns (fig. 2, A), and owing to the position which they occupied in their cells, they diverge a little from each other when thus extricated. It is clear that if an insect after

plundering the nectary of one flower, flies away to visit another, it will insert the pollinium or pollinia that it may have extracted from the first into the corresponding part of the second, and, as Mr. Darwin remarks, the attached pollinium would simply be pushed into its old position, entirely avoiding the stigma, which is situated immediately below. To get over this difficulty one of the most remarkable "contrivances" of the whole series comes into play. It is described as follows by Mr. Darwin:—"Though the viscid surface," he says, "remains immovably affixed, the apparently insignificant and minute disc of membrane to which the caudicle adheres is endowed with a remarkable power of contraction, which causes the pollinium to sweep through an angle of about ninety degrees, always in one direction, viz., towards the apex of the proboscis or pencil, in the course of thirty seconds on an average. The position of the pollinium after the movement is shown at B in fig. 2. After this movement, completed in an

FIG. 2.



POINT OF A PENCIL WITH POLLINIUM OF ORCHIS MASCULA ATTACHED TO IT, IN TWO POSITIONS.

A. The position of the pollen-mass when first attached.
B. Its position after the act of depression.

interval of time which would allow an insect to fly to another plant, it will be seen by turning to the diagram (fig. 1, A), that if the pencil be inserted into the nectary the thick end of the pollinium now exactly strikes the stigmatic surface." The viscidity of the surface of the stigma causes the pollinia to adhere to it; but the peculiar composition of the latter, consisting as they do of numerous packets of pollen-grains held together only by slender threads,* renders the breaking up of the pollinium an easy matter. Hence only a small quantity of the pollen-grains remains attached to the stigma, and thus a pollinium attached to the head of an insect may be applied successively to several stigmas and fertilize them all. Mr. Darwin says that he has often seen the remains of the pollinia of another species of *Orchis* "adhering to the proboscis of a moth, with the stump-like caudicles alone left, all the packets of pollen having been left glued to the stigmas of the successively visited flowers."

Of the reality of this process no doubt can be entertained. The actual phenomena of the removal of the pollinia may be produced experimentally,

* It is evidently to the degree of coherence of the pollinia, and not, as Mr. Darwin seems to think, to the degree of viscidity of the stigma, that the breaking up of the former is to be ascribed.

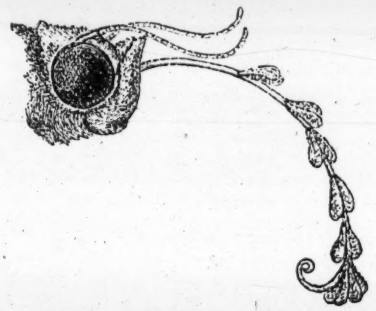
as already indicated, by the insertion of some suitable pointed object into the orifice of the nectary in the common purple orchis; after their removal the change of position may be directly observed; the fact that the whole of these operations are effected in nature by the agency of insects, is demonstrated by the frequent presence upon their heads and proboscides of the pollinia of various species of orchids; and these facts, coupled with the position assumed by the pollinia when thus attached, adapting them for being brought into direct contact with the stigmas of other flowers, and with the impossibility in most species of the pollen reaching the stigma by any other means, may be regarded as furnishing an irrefragable body of evidence, from which we may with no great difficulty infer that the whole of these contrivances, so wonderfully correlated as they are, are directed to one special object, namely the fecundation of one plant by the pollen of another. For the advantages gained by the intercrossing of distinct individuals of plants, the reader may consult Mr. Darwin's book, "On Cross and Self-fertilization," noticed in our last number, in which one side of the question at all events is thrown into high relief; perhaps the broadest and most general effect of this intercrossing of individuals of the same species is to keep the species "true," by its tendency to efface indifferent individual variations.

But whatever opinion we may form as to the purpose in nature of this apparent necessity for at least an occasional intercrossing of individuals of the same species of plants, there can be no doubt that in nearly all the orchids we find what may be called most careful provisions made to secure that the fertilization of the ovules in a given ovary shall not be effected by the pollen of the same flower, nor in a general way, by that of the same plant. The number of known self-fertilizing species is very small; they will be found referred to in Mr. Darwin's book. In all the rest the flower shows "contrivances," as Mr. Darwin calls them, for securing the removal of the pollinia by insects visiting the flowers, although the precise nature of these arrangements is by no means the same in all.

Several species of *Orchis* show the same arrangements as *Orchis mascula* just described, and it would appear that bees, humble-bees, and flies are the chief agents in transporting the pollinia of these species. In the Pyramidal Orchis (*O. pyramidalis*) the general arrangement of the parts is very similar to that which occurs in *O. mascula*, but the caudicles of the pollinia, instead of being attached to two separate membranous discs separated from the upper and posterior surface of the rostellum, are affixed to a single saddle-like piece, representing the two discs above mentioned united, and this, which is also strongly viscid beneath, not only adheres by its under surface to the object that sets it free by pushing down the pouch of the rostellum, but actually clasps and embraces the object, which, in nature, is usually the proboscis of some moth or butterfly. This clasping not only aids in fixing the pollinia to their means of transport, but also serves to produce a divergence of the pollinia, which, by this means and by the subsequent contraction of the membrane (as in *O. mascula*), are brought into a proper position for contact with the stigma of another flower. The moths and butterflies which frequent these flowers, are actually compelled to insert the proboscis into the nectary in such a direction as will bring them into contact with the rostellum, by means of certain guiding plates placed on the labellum, and in

this way as they go from flower to flower, they often accumulate two or three or even more pairs of pollinia. One specimen of a noctuid moth (*Acontia luctuosa*) had no fewer than seven (see fig. 3), and a specimen of a *Caradrina* eleven pairs of pollinia attached to the proboscis. "The proboscis of this latter moth," says Mr. Darwin, "presented an extraordinary arborescent appearance. The saddle-formed discs, each bearing a pair of pollinia, adhered to the proboscis, one before the other, with perfect symmetry; and this follows from the moth having always inserted its proboscis into the nectary in exactly the same manner, owing to the presence of the guiding plates on the labellum. The unfortunate Caradrina, with its proboscis thus encumbered, could hardly have reached the extremity of the nectary, and

FIG. 3.



HEAD AND PROBOSCIS OF ACONTIA LUCTUOSA, WITH SEVEN PAIRS OF THE POLLINIA OF ORCHIS PYRAMIDALIS ATTACHED TO THE PROBOSCIS.

would soon have been starved to death. Both these moths must have sucked many more than the seven and eleven flowers, of which they bore the trophies, for the earlier attached pollinia had lost much of their pollen, showing that they had touched many viscid stigmas."

From the examples furnished by these common British orchids, the reader may understand the general principle upon which the fertilization of the seeds is effected in the plants of that family. The process throughout is the same, modified in certain details, but always, except in the few species known or supposed to be self-fecundating, involving the attachment of a disc, forming part of the rostellum and bearing pollinia, to some part of the head of an insect, which thus conveys the fertilizing agents to other flowers. We shall not attempt, nor indeed would our space permit us to follow Mr. Darwin through his description of the details of the process in the various groups of orchids; for while any such attempt could only prove a failure, it might also have the effect of inducing our readers to avoid the perusal of one of the most charming natural history books that ever issued from the press. Otherwise we should have liked to give some account of the case of *Catasetum*, one of the most curious and interesting of the whole, in which the pollinia, attached to a common pedicel, which in its turn is attached to a viscid disc, are actually, as it were, shot out, disc forwards, as soon as any object comes in contact with the tentacle-like organs which here represent the rostellum. The whole of that portion of Mr. Darwin's book which is devoted to the description of the observed phenomena will be read with the greatest pleasure by everyone possessing some taste for

natural-history studies, and its perusal will open up a treasury of fresh interest for those who have the opportunity of practically following out the course of observations detailed in it.

The volume, moreover, contains dissertations upon various questions which arise naturally from the consideration of the phenomena to which we have briefly and very imperfectly called attention, questions which must possess great interest for the scientific botanist, such as the actual homological explanation of the structure of the flowers in the group of Orchids, the gradations in the mode of development of their various organs, the effects of the recognition of these gradations upon the phylogeny of the group, and the mechanism by which the peculiar phenomena of their fecundation are brought about. To enter upon any detailed exposition of the results of Mr. Darwin's investigations in these various directions would occupy much more space than we have at our disposal, and we must therefore refer the botanical reader to the book itself, which is certainly one of the most fascinating volumes that it has ever been our lot to study.

This second edition has received very considerable additions, not only arising out of the author's own observations, but also derived from the very numerous memoirs which have been published on the subject since Mr. Darwin first called attention to the curious facts revealed by the investigation of the orchids, some fifteen years ago. The illustrations, which are nearly the same as those printed in the first edition, have received some few additions; they are very carefully selected and executed, and serve to render all the details most readily intelligible.

THOMÉ'S TEXT-BOOK OF BOTANY.*

PROFESSOR THOMÉ'S "Text-book of Botany," which, as the Editor, Mr. Bennett, tells us, is the recognized book in use in the technical schools of Germany, will no doubt meet with great and well-deserved success in its English dress. Its descriptions of structure are exceedingly clear and intelligible, and the arrangement of the subject will be found to conduce greatly to a ready understanding of the internal and external anatomy of plants, in which the student will find further assistance in the very numerous and excellent illustrations. In this and the physiological section, Mr. Bennett has closely followed the German original, appending new additional information in the form of footnotes. But in the succeeding chapter, which treats of the morphology of plants, and the classification founded upon it, the Editor has departed from this rule, and while retaining his author's treatment of the Cryptogamia, he has introduced a classification of the flowering plants in accordance with the system most generally accepted in this country. The sections on Palæophytology, and on the geographical distribution of plants, although brief, are good; and the latter is illustrated by a coloured map.

* "Text-book of Structural and Physiological Botany." By Otto W. Thomé. Translated and Edited by A. W. Bennett, M.A., &c. Small 8vo. London: Longmans. 1877.

MR. DARWIN'S GEOLOGICAL OBSERVATIONS.*

IN publishing the volume of "Geological Observations" now before us, Mr. Darwin has performed a feat parallel to that of the elder Mr. Shandy, which, as that gentleman's son tells us, was calculated to make the man in the moon beat his breast in despair, and apostrophize the "eternal Maker of all beings" to know why the moonites should be incapable of such ingenious flights. He has brought out a second edition of a book of which the first never appeared. The volume, in fact, contains a reprint, apparently without alteration, of two treatises published by Mr. Darwin shortly after his return from the exploring voyage of the *Beagle*; namely, his "Geological Observations on Volcanic Islands" and his "Observations on South America," which appeared respectively in 1844 and 1846.

Both these works have now been out of print for some time, and as the observations described in them are of the highest importance, and the books themselves are constantly referred to in all general treatises on geology, their author has certainly conferred a boon upon students, whose only chance of obtaining them was the picking up of an occasional second-hand copy, by republishing them in so convenient a form. The only thing we can wish is that, as the knowledge of the volcanic rocks has made such prodigious strides of late years, Mr. Darwin had appended to the first of these treatises such notes as would have sufficed to bring the statements contained in the text into accordance with modern views and nomenclature. The maps and illustrations are the same as in the original edition.

THE PUZZLE OF LIFE.†

THE object of the author of this little book is to furnish children with a sketch of the general facts of geology and palæontology, and the meaning of its title may be explained as follows: The various fossils which give us a notion of the succession of life upon the earth are compared to the "pieces" of a dissected puzzle, and the outline of geological facts furnishes its "framework." The idea is a happy one and will recommend itself to children; and we are bound to say that Mr. Nicols has carried out his idea remarkably well, and produced a work which will do much to spread sound notions upon the gradual development of our earth and its inhabitants to the condition in which we now see them. Here and there, in his anxiety to make a point, Mr. Nicols travels a little beyond his tether, as when he says "that it is not untrue to call coal 'compressed sunlight,'" a remark which

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* "Geological Observations on the Volcanic Islands and parts of South America, visited during the voyage of H.M.S. *Beagle*." By Charles Darwin, M.A., F.R.S. Second Edition, with maps and illustrations. 8vo. London: Smith, Elder & Co. 1876.

† "The Puzzle of Life, and how it has been put together; a short History of Vegetable and Animal Life upon the Earth from the earliest times, including an account of Prehistoric Man, his weapons, tools, and works." By Arthur Nicols, F.R.G.S. Sm. 8vo. London: Longmans. 1877.

requires to be taken with many grains of a salt which will hardly be at the command of his youthful readers; and when he proposes to give to "black-lead" the name of *Eodendron*, or the "dawn plant." The application of the term "Lilliputian giants" to the Foraminifera is an absurdity which we hope the author may have a speedy opportunity of getting rid of, with some others, in a new edition. The illustrations are of the ordinary character in elementary geological books, and neither good nor bad in their execution, but we would suggest that it is not desirable to figure an Ammonite from the Inferior oolite as a Cretaceous fossil; and that the skeleton of the mammoth would look better with jointed toes in his feet than with blocks of wood, especially when his living outline is indicated *en silhouette*. On the whole, however, we can safely recommend Mr. Nicols' little book as one that will have a most beneficial effect in opening the minds of its young readers.

THE HISTORY OF LIFE ON THE EARTH.*

THE youthful student, after mastering the contents of Mr. Nicols' little book, may, if he feels that way inclined, continue his studies in the same direction under the guidance of Professor Alleyne Nicholson. That gentleman's "Ancient Life-history of the Earth" in fact covers precisely the same ground as the elementary work just noticed, although of course the subject is treated in a much more scientific fashion, and in much greater detail.

Dr. Nicholson's book, although at the first blush it might seem to be merely a *réchauffé* of his "Manual of Palæontology" served up in a new dish, and with a different arrangement of the parts (a sort of publication to which we are pretty well accustomed nowadays), is in reality a new book, and one which will be exceedingly useful to students, and especially to those who are carrying on geological and palæontological investigations in more or less isolated situations. The great body of the work consists of a history of the different formations of the earth's crust, as illustrated by their fossils; and in preparing this, as a matter of course, the materials contained in his "manual" must have stood in him good stead; but the stratigraphical mode of arrangement of these materials has compelled the author to give a general sketch of the characters and subdivisions of each of the great geological formations; and these successive sketches, although necessarily very brief, convert his present work into a manual of stratigraphical geology, distinguished from other works of the same nature chiefly by the great prominence given to the palæontological side of the subject. As an introduction also, Dr. Nicholson has given his readers an outline of the principles of physical geology so far as these are necessary for the due comprehension of the special subject matter of his book, and this appears to be written with great fairness, and with a clear appreciation of those points which may be regarded as still *sub judice*.

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* "The Ancient Life-History of the Earth: a comprehensive outline of the principles and leading facts of Palæontological Science." By H. Alleyne Nicholson, M.D., D.Sc., &c. 8vo. Edinburgh and London: Blackwood. 1877.

There is one feature in this volume which we are particularly glad to see, namely, the short bibliographical summaries at the close of each section. Most elementary books seem to be written as if the authors thought that they had told everything that anybody could possibly want to know; and many a student, after exhausting the limited supply of intellectual pabulum which they present to him, must have sighed in vain for some friendly guidance to those richer pastures in which perhaps his late teacher had gathered the materials for the insufficient banquet. Of course in a small work like the present, it would be unfair to expect a complete list of the works of reference to which the student should have recourse; but our author has given a very judicious selection of them, and has even indicated in many cases where the more recent scattered papers of importance are to be found, even when he abstains from giving their titles. In every respect Dr. Nicholson's little work will be found an excellent guide to an acquaintance with the subject of which it treats. The illustrations, a good many of which are new, are numerous and good, but we once more meet with our friend the mammoth with wooden feet. It is really hard upon this unfortunate animal that he should be pictorially handed down to posterity in this condition.

HISTOLOGICAL DEMONSTRATIONS.*

IT is no great wonder that these "Histological Demonstrations" have reached a second edition, for the book, which is founded upon the lectures of Dr. George Harley, edited by Professor G. T. Brown, is one of the most useful guides that the student could have in the practical study of microscopic anatomy. The first section of the book gives an account of the methods of investigation and the instruments employed, the structure and principles of the microscope, and the mode of preparation of the objects to be examined. The authors then describe the various tissues, and their combinations in the different organs of the animal body in a healthy state; and from these they pass to that most important subject to the medical student—the investigation of the morbid conditions and products of different parts of the organism. The whole of this portion of the book seems to be very well done; it furnishes an excellent summary of the present state of knowledge, with clear directions to the student as to the best methods of seeing for himself what is here described. The concluding section of the book treats of the parasites of man and of some animals, and in the first portion of this at any rate the authors are not particularly successful, especially when they place the wingless dipterous parasite, *Melophagus ovinus*, under their group "Ixoda" because it is called a tick. The part relating to the Entozoa is more satisfactory, although rather scanty in its details. This book is very freely illustrated with woodcuts, which are for the most part good and characteristic. It has also a coloured frontispiece, representing a section of the injected molar tooth of a cat.

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* "Histological Demonstrations: a Guide to the Microscopical Examination of the Animal Tissues in Health and Disease; being the substance of Lectures delivered by George Harley, M.D., F.R.S." Edited by George T. Brown, M.R.C.V.S. Second Edition. 8vo. London: Longmans. 1876.

WINDS OF DOCTRINE.*

UNDER the title of "Winds of Doctrine," which we cannot but regard as somewhat unhappily chosen, although from a certain point of view the satire of the allusion is not without its force, Dr. Elam has published an assault upon the citadel of the doctrine of evolution. The point of the title is to show that Dr. Elam considers those whom he assails "unstable as water," and in the apostolic phrase "carried about with every wind of doctrine;" and the points that he attacks are the modern theory of evolution and the doctrine of automatism which has been founded upon it by some leading scientific men of high standing. It may be remarked, however, as indicating the author's standpoint, that while both he and his antagonists derive the doctrine of automatism from that of evolution, he places the derivative first in order, which may be taken to show that his objection to the theory of evolution depends rather upon its supposed consequences than upon its own demerits.

With regard to automatism Dr. Elam, by a long series of quotations from various writers, especially Professors Huxley and Tyndall, and Mr. Herbert Spencer, succeeds, we think, in demonstrating that his opponents have pushed matters too far; and in his inability to comprehend the nature of "an automaton endowed with free will," we can most certainly sympathize with him. But with all due deference to the distinguished philosophers who have derived this doctrine of automatism, pure or modified, from the theory of evolution, we cannot think that the former is by any means a necessary consequence of the latter; and we fancy that a very great number of naturalists who believe in the origin of species by descent with modification will be found to be of our opinion. Without going in for any spiritualistic doctrine whatever, we think it quite possible to see in organised beings qualities quite incompatible with the mechanical theory of life; and in reality, with our present knowledge, it is impossible to say that that theory is the true one.

At the same time we may remind Dr. Elam, if his argument has been urged, as would appear to be the case, in the theological interest, that a very considerable section of the Christian world holds opinions which if logically carried out to their consequences involve the notion of human automatism as inexorably as the materialistic conception against which he has couched his lance; and in fact that the very notion of a personal deity, unless we choose arbitrarily to abridge his attributes, may easily be shown to be incompatible with human free-will. But, as Prof. Huxley says, in one of the passages quoted by Dr. Elam:—"Why trouble ourselves about matters of which, however important they may be, we do know nothin g and can know nothing?" These matters have been discussed in all times; in fact if we are to believe Milton, even the devils discoursed of fate, free-will, and foreknowledge, before man made his appearance on the face of the earth, though what possible interest devils could feel in such questions is

* "Winds of Doctrine: being an Examination of the Modern Theories of Automatism and Evolution." By Charles Elam, M.D. 8vo. London: Smith, Elder & Co. 1876.

rather hard to see. We will therefore leave them to Dr. Elam and his opponents, with the expectation that their discussion will be about as easily terminated and as profitable as the celebrated dispute, recorded by the learned Slawkenbergius, between the Catholic and Lutheran doctors of Strasburg with regard to the reality of the courteous Diego's long nose.

A question scarcely less puzzling than those just alluded to is that of the origin of life and of organizable material, and here again our author falls foul of Prof. Huxley. To some of the arguments used by the latter Dr. Elam replies as follows :—"It is in no sense true that protoplasm 'breaks up' into carbonic acid, water and ammonia, any more than it is true that iron, when exposed to the action of oxygen, 'breaks up' into oxide of iron. A compound body can only break up into its constituent parts ; and these *are not* the constituent parts of protoplasm. To convert protoplasm into these compounds requires an amount of oxygen *nearly double the weight* of the original mass of protoplasm; every 100 lbs. of protoplasm would require 170 lbs. of oxygen. Again :—"Under no 'possible conditions,' can carbonic acid, water and ammonia, when brought together, 'give rise to the still more complex body, protoplasm.' Not even on paper can any multiple, or any combination of these substances, be made to represent the composition of protoplasm, much less can it be effected in practice." It must be confessed that this argument looks very strong, and perhaps as opposed to the mechanico-chemical hypothesis of the origin of life it is as strong as it looks; but at the same time although carbonic acid, ammonia and water constitute the food of plants growing at the present day, and their nourishment is effected with elimination of oxygen, we do not know what method of combination may have occurred "under certain conditions," as Prof. Huxley says, and it may be added at a certain time. What the conditions were may perhaps always remain unknown ; but even if we never discover them and are thus left in the dark as to the actual origin of life upon the earth, this need not in any way invalidate the doctrine of the origin of species by evolution, which rests its claims to acceptance upon very different grounds.

In his argument against the doctrine of evolution, Dr. Elam employs with great vigour all the weapons that have been prepared to his hand by the writings of those who maintain its truth, or at any rate its probability. But it must be remarked that the publication of those writings extends over a considerable period of time, during which the views of the writers have in many cases advanced considerably, so that, except for historical purposes, it is hardly fair to quote the whole of them as expressive of their opinions. Thus the author quotes a long passage from a paper published by Prof. Huxley in 1862, in which that distinguished naturalist affirmed that the study of palæontology negatives the doctrine of evolution ; and although he afterwards cites the Professor's address to the Geological Society in 1870, in which there is said to be "a clear balance in favour of the evolution of living forms one from another" among the higher Vertebrata, he passes this over slightly and proceeds again to cite opinions expressed in 1860 and 1863. The main cry, in fact, is that of want of evidence from both the palæontological and the experimental side, the latter being of course the most crucial test to which the doctrine can be exposed. We fear that the test of actual experiment will be always impossible of application, but most

decidedly the weight of the evidence from palæontology in opposition to the theory of evolution has always been greatly exaggerated. So far from there being an absence of transitional forms among fossils, every palæontologist knows that their constant occurrence is one of his greatest plagues; and there is little doubt that by tracing any group of forms with the requisite exactitude through a series of successive deposits, the most convincing proof, short of absolute demonstration, of the interdependence of the successive so-called species might be obtained. So far as geographical distribution is concerned, the doctrine of the origin of species by descent with modification is the only one that furnishes us with any rational explanation of the facts observed; and the numerous examples of species differing but slightly from each other in neighbouring but isolated situations, such as the beetles described by Mr. Wollaston from the Cape Verde Islands, which he himself, although strongly anti-evolutionist, could not believe to have been the products of separate creations, many aquatic animals in Alpine lakes, and the freshwater representatives of marine types, with many others, seem to demonstrate, so far as observation can do it, the derivative nature of the varied forms of life.

ARNOTT'S ELEMENTS OF PHYSICS.*

THIS may be called the first posthumous edition of the well known work of Dr. Arnott. A man who in his lifetime gave considerable sums of money for the advancement of Natural Philosophy, and made a present to the public of his valuable inventions by refusing to patent them, was undoubtedly one who took great interest in Physics; yet he approached the subject, as we may say, as an outsider, coming to it from the point of view of a medical man. There are decided advantages in a book written by such an author, as likely to contain more of the practical bearings of the subject than one prepared by a professed physicist; and possibly, as in this case, to range over a wider field as included in the subject. There are few works on the elements of physics which border so closely on physiology as this does in the part devoted to animal mechanics, hydraulics, and pneumatics. At the same time, however, that the public generally will find here what they want, to the professed student it would be of little use. For him its range is *too* wide, rendering necessary a too fragmentary outline of each subject; and it is written with too little accuracy for his purpose. It is indeed rather a singular spectacle to see a book on physics written by a medical man, and edited by a Professor of Logic and an eminent Toxicologist. The editors have had the assistance of Mr. Cook, formerly Assistant-Professor of Natural Philosophy at Aberdeen, in the revision and adaptation of the work; and to him is probably due the presence of several valuable

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* "Arnott's Elements of Physics or Natural Philosophy." Seventh Edition. Edited by A. Bain, LL.D., and A. S. Taylor, M.D., F.R.S. Small 8vo. London: Longmans. 1876.

notes, adding to or correcting the text, but we cannot say that the result is that the work is thoroughly reliable as far as it goes, or that it contains all that we might naturally expect it to contain. A few corrections that *might* have been made it may be well to notice.

First we are told that "all molecules are not atoms, though all atoms are molecules;" and we wonder why this false statement was not expunged, as the right one is given as a note. In the section relating to heat, we have the error too often found in the explanation of Franklin's experiment, a new form of which experiment has lately been introduced to the public as a toy, under the name of "Barometer of Temperaments;" viz., that the "warmth of the hand grasping one bulb will form steam, causing all the water to pass rapidly to the other and to boil there;" whereas it is really only the expansion of the warmed air that drives it *through* the liquid, and makes the latter *appear* to boil. Again with respect to the tides; it is doubtful whether any meaning can be attached to the following sentence that would make it correct: "The tide on the distant side of the earth is the effect of the centrifugal force not fully balanced by the attraction of the moon." Once more, though it is a question of physiology rather than of physics, it is more than doubtful if a man is fatigued four times as much by going upstairs, when he goes four times as slowly as another.

These instances will show that the book cannot be relied on as a standard, but the same might be said of others, and among similar works this is perhaps the best.

ANTHRACENE *

THIS is a systematic treatise on a subject which both in its scientific and technical aspects is of the utmost interest and importance. The perusal only of the bibliographical index at the end of the volume gives some idea to those who have been engaged on researches in organic chemistry of the immense amount of time, intellect, money, patience, knowledge, and experimental skill bestowed on the study of anthracene and its derivatives. Much of this labour has been undertaken without any hope of pecuniary gain, but from motives which actuate all purely scientific work, the desire to acquire and advance knowledge. Chemists, especially those who are not technologists, are too apt to regard the dependence of technology upon pure science without acknowledging the debt which science owes to technology. The immense amount of research made within the last ten years on anthracene and its derivatives, would never have been accomplished had not Græbe and Liebermann's synthesis of alizarine from a product of tar-distillation been carried out as an industrial enterprise, thus affording abundance of material to work upon. The same thing may

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* "Anthracen; its Constitution, Properties, Manufacture, and Derivatives, including Artificial Alizarin, Anthrapurpurin, &c., with their applications in Dyeing and Painting." By G. Auerbach. Translated and Edited from the revised Manuscript of the Author, by W. Crookes, F.R.S. 8vo. London: Longmans & Co. 1876.

be said of much of the chemistry of the so-called aromatic compounds; it dates from the time when there was a commercial demand for coal-tar products. We do not of course wish to underrate the influence of Kekulé's theory of the constitution of these substances, without which we might still be groping in the dark. The volume before us gives the preparation, purification, and valuation of anthracene, its conversion into anthraquinone and the sulpho-acids. The various processes for the preparation of artificial alizarine are carefully described, and the difficulties involved are mentioned. The methods best adapted for preparing pure specimens in the laboratory are given, as well as those commercially practicable. According to the now accepted formula of anthraquinone, there are nine possible compounds isomeric with alizarine; and of these eight are actually known, though scarcely with sufficient accuracy. These are, anthraflavic acid, iso-anthraflavic acid, anthraxanthic acid, quinizarine, chrysazine, frangulic acid, xanthopurpurine, and isalizarine. Some of these are capable of dyeing mordanted tissues. From what is known of their constitution, it seems probable that only those derivatives of oxyanthraquinone are dyes which have two hydroxyl groups situated in the same benzole nucleus. To a student this work is suggestive of much research, but it requires that one should know something of organic chemistry to appreciate its value. An evident misprint, ferrous for ferric salts, occurs on page 157. We are much indebted to the translator for bringing into notice and making easily accessible the immense fund of scattered information collected in Mr. Auerbach's valuable work.

ZOOLOGICAL CLASSIFICATION.*

IT is not an easy task to compress a whole system of zoological classification into a volume small enough to be conveniently carried in the pocket; but this is what Mr. Pascoe has attempted to do, and it must be confessed with a very considerable amount of success, in a little work just published under the above title. As a matter of course the reader need not look for an exhaustive treatise on zoology in a book containing only about 200 very small octavo pages, and indeed the author himself makes no claim to have produced anything of the kind, his object being, as he tells us in his preface, to furnish "a convenient work of reference on the classification of the animal kingdom, and to bring the contents of the various groups under the eye in the most concise form."

This modest purpose Mr. Pascoe has certainly fulfilled in a very creditable manner. His little book is an excellent work of reference; for although, perhaps, it would not be possible for a beginner to take it up and learn much zoology from its pages, the student, as he progresses, will find it a most excellent aid in correlating the knowledge that he acquires, in determining the relations and the precise position in the animal kingdom of

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* "Zoological Classification: a Handy Book of Reference, with Tables of the Subkingdoms, Classes, Orders, &c. of the Animal Kingdom, their Characters, and Lists of the Families and principal Genera." By Francis P. Pascoe, F.L.S., &c. Small 8vo. London: Van Voorst. 1877.

animals and groups of animals that he may meet with in nature or find referred to in other works, and in keeping constantly in his mind the general principles of zoological classification.

Starting with the Protozoa, Mr. Pascoe works his way upwards through the Animal Kingdom, which he divides into seven subkingdoms, the Protozoa, Cœlenterata, Echinodermata, Vermes, Arthropoda, Mollusca, and Vertebrata; or eight, if the Sponges, which, in accordance with the views of Häckel and Leuckart, he places among the Cœlenterata, are treated as a distinct subkingdom. For our own part, we cannot regard the sponges as forming either a separate subkingdom or a portion of the Cœlenterata; their affinities seem manifestly to be with the Protozoa. All these subkingdoms, and the classes and orders included in them, are briefly characterized, and the short diagnostic phrases are generally followed by a few concise notes on the structure and natural history of the animals composing the groups. Moreover, the whole of these groups are tabulated in a manner which, although generally rather artificial, will aid the student greatly in finding his way through the labyrinth of zoological classification. Under the orders the author indicates by name the families into which they are divided, and gives a list either of the whole of the genera composing them, or of a selection of the best known and most characteristic of those groups. This last feature, although, perhaps, the lists of genera may appear like so much space wasted to a mere reader of the book, is really a most valuable addition for the purposes of the student, for, with the help of the index, it furnishes him with a sort of dictionary of some 1,500 generic names, such as may crop up and form stumbling-blocks in his path at any moment.

That we do not agree with Mr. Pascoe in all his notions of classification need hardly be stated. A zoologist who in the present day could promulgate a system with every part of which any other zoologist would be perfectly satisfied, ought to be publicly exhibited as the last and greatest wonder of the world. But in the present instance our author has greatly weakened the force of any objections that we could urge against certain parts of his book (such as that relating to the position of the sponges already referred to) by indicating generally, in doubtful cases, the existence of opinions at variance with those adopted by him; and we must remark further, that while he has evidently studied the most recent attempts at zoological classification, he has wisely allowed himself to be very sparingly influenced by some of the wilder speculations on the subject.

Here and there in his references to quite recent authors, and especially with regard to the phenomena of so-called alternation of generations, the author seems to us not to have quite realized the significations of terms, and his descriptions are in consequence more or less erroneous or obscure; but these are only small defects, and on the whole we can heartily recommend Mr. Pascoe's little volume to all students of zoology who want "a handy book of reference."

FOWNES' CHEMISTRY.*

WE need hardly do more than announce the publication of the first volume of a new edition of the late Dr. Fownes' well-known "Manual of Chemistry." It is now brought out under the sole editorship of Mr. Henry Watts, who has evidently done all in his power to render the book worthy of the high reputation it has always enjoyed as a student's text-book; in fact, so much has he added to the present edition, in consequence of the rapid advance of chemistry of late years, that the matter has become too extensive for a single volume, and the editor has been compelled to adopt the expedient (a somewhat dangerous one from a commercial point of view) of issuing the work in two parts.

The arrangement of the matter is the same as in the former editions, and the first volume, now before us, is devoted to Chemical Physics and Inorganic Chemistry. The treatise on the former set of subjects, although necessarily brief, furnishes an exceedingly satisfactory outline, more than sufficient for the ordinary requirements of the student, and embodying many of the most recent results of chemical research. The purely chemical portion, which occupies nearly four-fifths of the book, is also very good and well worked up. The editor has retained the author's original plan of placing the section treating of the general principles of Chemical Philosophy at the conclusion of that devoted to the non-metallic elements, but he has to a certain extent anticipated some of its teachings by appending to the article on Oxygen, or rather, perhaps, combining with what is said on Oxides, a brief exposition of the general laws of chemical combination, with an explanation of what is meant by chemical equivalents, and their use in representing chemical actions by equations. All these matters receive a more detailed and exceedingly philosophical treatment, in the section specially devoted to them, following those descriptions of the non-metallic elements and their compounds, an acquaintance with which and with the phenomena of their production, is undoubtedly a necessary preliminary to the due understanding of these general principles. As far as it has gone this new edition of "Fownes' Manual of Chemistry" appears to us to be one of the best, if not the best, handbook that the English student possesses.

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* "Fownes' Manual of Chemistry, Theoretical and Practical." Vol. I., "Physical and Inorganic Chemistry." Twelfth Edition, revised and corrected by Henry Watts, B.A., F.R.S. 8vo. London: J. & A. Churchill. 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

ANCIENT Sources of Tin.—Professor Karl Ernst von Baer, only a few days before his death, prepared a paper on this subject, which has been published in the "Archiv für Anthropologie." From the circumstance that almost all the ancient bronzes are found to contain the same proportions of the constituent metals, he is inclined to think that the use of bronze had spread from some single centre. The source of the tin used in the fabrication of bronzes found in the Assyrian and Babylonian ruins he thinks may be found in Khorassan, where the existence of the metal was revealed by some inquiries that he set on foot, having been led to the belief in its occurrence in that region by a statement of Strabo's. The tin employed in Scandinavia and the countries surrounding the Mediterranean before the discovery of the Cornish mines, is supposed by Von Baer to have been probably brought by the Phœnicians from Banca!

The Bulgarians.—According to a report in "Nature" (February 22, 1877), Professor Virchow lately communicated to the Anthropological Society of Berlin, the results of numerous craniological measurements undertaken in Bulgaria. The general type is said to be evidently not Sclavonic but Finnish, and to point apparently to an emigration from the Turco-Finnish tribes of the Oural, to the region of the Danube. Two distinct subordinate types are noticed; one brachycephalic, regarded as pure Finnish; the other macrocephalic, with a retreating forehead, strikingly resembling that of the Australian negro. The Bulgarians must have gradually adopted the Sclavonic language, and no trace remains of their original tongue.

ASTRONOMY.

Photographs of Stellar and Planetary Spectra.—It is rather singular that while American and English astronomers succeeded almost simultaneously in solving the difficult problem of estimating the rotation of the sun spectroscopically, they should in like manner have attained almost simultaneously the mastery of another difficult task. At Mr. Huggins's Observatory, arrangements have been in progress during the last two years for applying photography to the spectra of the stars. For this purpose Mr. Huggins has replaced the 15-inch refractor before used by him with a reflector 18 inches in diameter. The motion of the driving clock was found

to be not sufficiently uniform, and the services of Mr. Grubb were called in, who successfully applied to the clock the control of a seconds pendulum, in electric connection with a sidereal clock. The spectroscopic part of the apparatus was constructed with a prism of Iceland spar, and lenses of quartz. This apparatus was so arranged, that a solar or electric spectrum could be taken on the same plate for comparison with the spectrum of the star. After an extensive trial of difficult photographic processes, preference was given to dry plates. Among other advantages, a dry plate could be left in the apparatus until the following day, when a solar spectrum could be taken upon it through that half of the slit which was closed when the instrument was directed to the star. During 1876, spectra were obtained with distinct lines from Sirius, Vega, Venus, and the Moon, in juxtaposition with well-defined and well-detailed solar spectra. The American researches in the same direction have continued during a longer period. Dr. Henry Draper, of New York, well known as one of the first telescopists to obtain really useful photographs of the moon, has been engaged since the spring of 1872 making photographs of the spectra of the stars, planets, and moon, and particularly, among the stars, of *a* Lyræ (Vega), and *a* Aquilæ (Altair), with his 28-inch reflector, and 28-inch refractor. In the photograph of Vega, bands or broad lines are visible in the violet and ultra-violet region, unlike anything in the solar spectrum. Last October, Dr. Draper succeeded in taking photographs of the spectrum of Venus, showing a large number of lines. There seems in this spectrum to be a weakening of the spectrum towards H and above that line, of the same character which Draper has photographically observed to take place in the spectrum of the sun near sunset.

Singular Phenomena presented by Jupiter's Satellites.—Mr. Todd, of Adelaide, with his new 8-inch equatorial by Cooke, mounted in December, 1874, has made a very valuable series of observations of the phenomena of Jupiter's satellites during the last opposition of the planet, extending from June 13 to October 15, 1876. A very interesting phenomenon was observed more than once, independently by Mr. Todd and his assistant, Mr. Ringwood, when a satellite was on the point of occultation. Instead of disappearing gradually behind the planet, it was apparently projected on the disc, as if viewed *through* the edge of the planet, supposing the latter were surrounded by a transparent atmosphere laden with clouds. This curious phenomenon was noticed on two occasions at the disappearance of the first satellite, when it was thus distinctly visible through the edge of the disc for about two minutes before it was finally occulted. It is hardly necessary to point out that this appearance is readily explained when the theory is accepted which is described in Mr. Proctor's paper on Jupiter in our last number; but is entirely inconsistent with the theory usually adopted. Mr. Todd also bears witness to the constantly varying aspect of the surface of Jupiter. He was much impressed with some sudden and extensive changes in the cloud-belts, as though a violent storm was raging, changing their appearance within an hour or two, or even less, not only in their form, but also in their magnitude.

O. Struve's Companion to Procyon found to be an Optical Illusion.—Some surprise and disappointment was occasioned by the failure of the great tele-

scope at Washington to show the faint companion seen by O. Struve and his assistant Herr Lindemann, following the star Procyon at a distance of about 10″. The fact that recently that large telescope has shown other faint companions of Procyon, which neither Struve nor Lindemann could see, has led these observers to re-examine the subject with great care. The result has been to convince them that the phenomenon they had seen has no objective existence, but was the effect of an optical illusion, which causes them to see under certain circumstances a faint image or point of light at about 10″ distance from a bright star, and nearly in a horizontal line with it. They found this to be the case with Regulus, Capella, and Arcturus.

Orbit of Alpha Centauri.—Mr. Hind, the Superintendent of the "Nautical Almanac," having received from Lord Lindsay the result of two sets of measures of the angle of position of Alpha Centauri, made with the heliometer at Mauritius, in November, 1874, during Lindsay's expedition for observing the transit of Venus, in 1874, has attempted a further approximation to the elements of this most interesting binary. He employed the last orbit by Powell, of Madras, in forming equations of condition for the epochs of the most reliable mean results, depending on the measures of Sir J. Herschel, Capt. Jacob, Powell, and Lord Lindsay, at the same time admitting the angle for 1752·2 given by Lacaille's R.A. and Dec. The elements obtained by the solution of the equations are as follows:—

Peri-Astron Passage . . .	1874·85
Node	21°48′·0
Node to Peri-Astron, along orbit .	59°32′·1
Inclination	82°18′·4
Angle of Eccentricity . . (or e = 0·6673)	41°51′·5
Semi-axis Major . .	21″·797
Period of Revolution . .	85·042 years.

"It will be remarked," says Mr. Hind, "that Lord Lindsay's measures fall exactly at the computed time of nearest approach of the component stars in the real orbit. Probably a somewhat closer representation of the observed angles and distances might be obtained by repeating the process from which the above elements were deduced, but I defer any further computation in the hope of soon receiving measures made after the passage of the peri-astron. If for the annual parallax, a mean of Henderson's value, as corrected by Peters, and that by Mœsta, be taken, giving 0″·928, we find the mass of this system = 1·79 × Sun's mass, and for the semi-axis major of the orbit 23·49." It is noteworthy that the mass here obtained corresponds closely with that deduced from the assumption that the intrinsic luminosity of the surface of the component stars is equal to that of the sun's surface, and the mean density of the two stars equal to the sun's mean density.

Rotation of Saturn.—On December 7, Professor Hall, of the Naval Observatory at Washington, observed a well-marked white spot on the disc of Saturn, below the ring. From observations made by him upon the motion of this spot, on December 7, 10, and 13, he deduced a rotation period of 10h. 15m., a result in satisfactory agreement with that obtained by W.

Herschel from observations of the successive appearances presented by a belt during the winter of 1793–94, viz., 10 h. 16 m. 0·4 s.

The New Star in Cygnus.—Professor Schmidt gives the following tabular statement of the varying magnitude of the new star from November 24, 1876, the date of its discovery, to December 15, when it was last perceptible to the naked eye:—

	m.		m.		m.
Nov. 24.	2·97	Dec. 1.	5·27	Dec. 8.	6·44
„ 25.	3·03	„ 2.	5·47	„ 9.	6·55
„ 26.	3·14	„ 3.	5·65	„ 10.	6·64
„ 27.	3·38	„ 4.	5·81	„ 11.	6·71
„ 28.	4·06	„ 5.	6·00	„ 12.	6·79
„ 29.	4·74	„ 6.	6·16	„ 13.	6·86
„ 30.	5·06	„ 7.	6·32	„ 14.	6·92

The Planet Mars. — M. Flammarion has published a chart of Mars, in which he has not only altered several of the features shown in Mr. Proctor's chart, but has introduced several alterations in the nomenclature. Dr. Terby, of Louvain, has expressed strong objections to both orders of change, and in particular to the fact that while M. Flammarion's chapter on the geography of the planet is based almost entirely on the researches of M. Terby, due notice has not been given of the fact by M. Flammarion. The latter, in reply, has expressed the opinion that the matter is not worth controversy; to which M. Terby has objected, not ineffectively, that results which are not worth controversy should not have seemed worth abstracting without acknowledgment. M. Terby considers Mr. Proctor's chart altogether more correct than the new one, so far as M. Flammarion's chart is new, which is perhaps not saying much. This is not the first occasion by several on which M. Flammarion has honoured other students of astronomy by borrowing their results.

The Total Eclipse of the Moon.—Mr. T. Rand Capron, in an interesting account of the total eclipse of the moon on February 27, remarks that during total obscuration the moon shone with a diffused weak copper-tinted light, and with what appeared a marked deepening of the dusky tint towards the centre of the disc. At no time was the tint absolutely dark. The loss of light was, however, during obscuration very marked. At times a crimson scarlet tint, deeper and less mixed with yellow than the copper tint, was noticed. "This last tint," says Mr. Capron, "reminded me much of a crimson glow common during aurora, and which I also once distinctly remarked—of course in a weaker degree—in the zodiacal light. The colours, when seen telescopically with a low power, were but little reduced in strength; the illuminated part of the moon coming out of a steel-grey, an effect which also took place when an occasional mist cloud passed over the moon's face."

Opposition of Jupiter.—Jupiter will be at his first station on April 20th, at 2 A.M., in opposition at midnight on June 20th, and at his second station at 3 A.M. on August 20. It may be hoped that much will be done during the interval between April 20 and August 20, to observe Jupiter with special reference to the questions which have recently been raised respecting this interesting planet.

BOTANY AND VEGETABLE PHYSIOLOGY.

Hybrid Fruit of Orange and Citron.—M. Oudemans has observed a fruit half orange and half citron. Externally it had precisely the form and colour of a citron. Internally, four of the compartments presented the colour and taste of the flesh of a citron; the other five had the qualities of that of an orange. The formation of this fruit may be explained in two ways. The tree which produced it may have been a hybrid between *Citrus medica* and *C. aurantium*. Or the flower which produced the fruit may have belonged to one of the above species, and have been fecundated, at least partially, by pollen of the other. On the first supposition the case would be parallel to that of *Cytisus Adami*. On the second, which M. Oudemans regards as most probable, we should have a fresh instance of the influence of the pollen on the fruit.—*Les Mondes*, December 14, 1876.

History of Polyphagus Euglenæ.—Dr. L. Nowakowski has published (in Cohn's "Beiträge zur Biologie der Pflanzen," Heft 2, 1876) a most interesting and important memoir upon the history of this curious microscopic vegetable parasite, a member of the group of Chytridia, the true position and nature of which have always been somewhat doubtful matters. Most of them are parasitic upon other aquatic plants, generally adhering to the surface of their component cells and sending processes into the interior. The *Polyphagus*, however, devotes its attention to those well-known flagellate infusoria, the *Euglenæ*, which it attacks when they are in the helpless, resting stage of their existence. The spores of the parasite are furnished with a variable number, four or more, of delicate, radiating filaments, one of which coming into contact with a *Euglena*, at once pierces its integument and penetrates into the contained protoplasmic mass. It then rapidly increases in size, and usually emits other filaments which stretch out in search of more victims, whilst the body of the spore also increases in proportion to the success of its rootlike processes, and in course of time becomes a "pro-sporangium." From this a sort of vesicle is pushed out, which after a time becomes a zoosporangium, and from it a cloud of zoospores finally escapes. Dr. Nowakowski has observed a true process of reproduction in these curious parasites. He finds that the individuals present two forms—one large, and generally spherical, which is the female plant; the other smaller, and more or less club-shaped, which is the male. These two forms conjugate in the following fashion:—The contents of the female plant project through an opening in its cell-wall and form an oval mass, with which one of the processes of a neighbouring male plant comes into contact, when the contents of the two mingle and a zygospore is produced, from which a zoosporangium is developed, and this gives issue to a swarm of zoospores. From his investigations the author is inclined to refer the Chytridia to the Siphomycetes.

CHEMISTRY.

Phosphorescent Organic Bodies.—M. B. Radziszewski has lately published in the "Reports of the German Chemical Society" (1877, p. 70), a memoir

in which he shows that there are certain perfectly well-defined organic bodies which shine in the dark when they are in contact with an alcoholic solution of caustic potash. These bodies are: hydrobenzamide, amarine, lophine, and the crude product of the action of alcoholic ammonia upon benzile; and to these the author now adds ("Comptes Rendus," Feb. 12, 1877), paraldehyde $(C^2H^4O)^3$, metaldehyde $(C^2H^4O)^n$, aldehyde-ammonia $(C^2H^4{<}^{OH}_{NH^2})$, furfurine, $C^{15}H^{12}O^3N^2$, hydro-anisamide, $^{C^{24}}H^{24}O^3N^2$, anisidine, $C^{24}H^{21}O^3N^2$, hydrocinnamide, $C^{27}H^{24}N^2$, and hydrocuminamide. He ascribes this chemical phosphorescence to the slow combined action of the caustic potash and the oxygen of the air, and the intensity of the phenomenon is in proportion to the slowness of the action. The bodies are either polymeric aldehydes, or products of the action of ammonia on the aldehydes, from which aldehydes can be produced either directly or by the absorption of the elements of water, and it is to the slow oxidation of the aldehydes in the nascent state that the author ascribes the phosphorescence of these bodies.

Copper in Preserved Peas.—At the meeting of the French Academy of Sciences on February 12, M. Pasteur gave an account of the general results of an investigation made by him of the preserved peas ordinarily sold in Paris. Out of fourteen tins purchased at various shops ten were found to contain copper, sometimes to the amount of about $\frac{1}{10000}$ of the total weight, deducting the liquid, which always contains much less than the peas. The copper becomes fixed, especially in an insoluble state, in the solid matter of the peas, particularly in the leguminous part beneath the outer envelope. According to M. Pasteur nothing is easier than to detect the presence of copper in preserved peas. All those which present anything of the green tint of natural peas contain copper, those which are free from the metal having a yellowish tint. Although there is a difference of opinion as to the extent to which salts of copper are poisonous, M. Pasteur maintains that the practice of employing that metal to improve the appearance of preserved peas ought to be absolutely proscribed; and he suggests that if nothing more can be done the dealers in the articles so improved in appearance should be compelled to label their wares, "*Preserved peas, coloured green by salts of copper.*" He thinks, and perhaps justly, that they would find comparatively few buyers. In connection with the question of poisoning by copper we may refer to an extraordinary statement made by M. Rabuteau to the Academy of Sciences at the meeting following that at which M. Pasteur spoke as above ("Comptes rendus," February 19, 1877). M. Rabuteau noticed the case of a girl of 20 who took in the course of 142 days 43 grammes of ammoniacal sulphate of copper, and died of rapid tubercular disease *three months after taking the last dose of the poison.* The liver was analysed by M. Rabuteau, who found it to contain nearly 24 centigrammes of copper, its total weight being 1,474 grammes. Hence M. Rabuteau concludes that the salts of copper are far less poisonous than is generally supposed; and especially that it would be exceedingly rash to affirm that we have to do with copper poisoning in cases where eight or even twelve centigrammes of copper are found in the livers of persons who have died under suspicious circumstances.

Solid Carbon in Luminous Flames.—Dr. Heumann has continued his researches upon luminous flames, and in a recent memoir considers the question of the cause of luminosity in the flames of hydrocarbons, and comes to the conclusion that it is the presence of solid incandescent particles of carbon. He founds this opinion on the following proofs: the increased luminosity produced by chlorine, which, as is well known, has the property of separating carbon; the fact that a rod held in a flame gets coated with soot only on the lower side, whereas if the carbon were present as vapour it ought to be condensed by cooling, and therefore all round the body; the fact that a body when held in the flame is coated with soot, even though kept in a state of ignition; the fact that the particles of carbon can actually be seen in a flame when it is made to strike against a second flame or an ignited surface—the particles then become aggregated together to form larger masses, which become visible in the luminous mantle of the flame as so many brilliant points; the fact that the transparency of the luminous portion of a flame is not greater than that of a layer of smoke of the same thickness arising from the flame of burning oil of turpentine, which is known to be filled with particles of carbon; and that flames which unquestionably owe their origin to the presence in them of solid particles, give a shadow with sunlight precisely as do those of hydrocarbons, while luminous flames composed of gases and vapours only throw no such shadow ("Liebig's Annalen," December, 1876).

Alterations in Glass.—M. V. de Luynes finds that glass, when exposed to atmospheric action, may undergo very considerable alterations. Some glass from a skylight in the Conservatoire des Arts et Métiers, which appeared unaltered when looked at perpendicularly to its surface, showed, under certain angles, numerous striæ of remarkable regularity. When slightly heated, both surfaces of this glass exfoliated in the form of scales, the total weight of which was about $\frac{1}{72}$ of the whole weight of the glass. Analysis showed that the scales contained 77·8 per cent. of silica, whilst the unaltered glass had only 65 per cent. When a fragment of the glass was placed in hot water, the latter penetrated by fissures from the circumference to the centre of each scale. In other specimens the additional proportion of silica in the scales was approximately the same, namely, 77·6 and 78·4 per cent. against 65·8 and 68 per cent. in the unaltered glass. From the examination of his specimens, M. de Luynes has ascertained that the glass in them is hard to cut, that they act generally upon polarized light like tempered glass, and that some of the scales show distinctly coloured fringes. He thinks that the preservation of transparency even in glass so profoundly altered may lead to an explanation of the effect produced by the use of acid as a preventive of the irisation of window glass ("Comptes rendus," February 12, 1877).

GEOLOGY AND PALÆONTOLOGY.

Microscopical Examination of Sands and Clays.—At present the investigation of the minute structure of various rocks, especially those of the so-called igneous and metamorphic series, is greatly attracting the attention

of geologists; and Mr. Sorby, in his Presidential Address to the Royal Microscopical Society on March 7, 1877, has shown that similar examinations with the microscope of the constituents of sands, muds, and clays, may lead to exceedingly valuable results. The following is a slight abridgment of an abstract of his address published by Mr. Sorby in "Nature" of Feb. 22, 1877. The paper appears in full in the "Monthly Microscopical Journal."

"The scope of this subject, as treated by the author, included the identification of the true mineral nature of the various particles, and the determination of the nature of the rock from which they were originally derived; the chief aim being to trace back the history of the material to the furthest possible extent.

"After describing the manner in which the different kinds of deposits should be prepared, examined, and mounted as permanent objects, the author indicated the conditions necessary for satisfactorily seeing the various particles, and for observing their microscopic structure and optical characters. The particles of clay and the fluid-cavities in grains of sand are often so minute as to task the power of the microscope to the fullest extent, and some indeed are so small that their perfect definition may perhaps be impossible by any means at our command. The conditions under which many of the objects are visible are such that with highly convergent light and object-glasses of large aperture no dark outline is possible, and therefore they are quite invisible, but become quite distinct when the aperture is reduced to a moderate and appropriate amount. For this reason object-glasses of comparatively small aperture are far the best, since the focal point being further from the front lens, very high powers can be used in cases which are beyond the reach of lenses of large aperture.

"The author then went into much detail to show the character of the grains of quartz, mica, and other minerals derived from the decomposition of various crystalline rocks, and showed that on the whole there are many characteristic differences between the material derived from granitic and schistose rocks, consisting mainly in the form, internal structure, and optical characters of the constituent grains; the general conclusion being that a careful study of sands, muds, and clays enables us to form a very satisfactory opinion as to whether they were derived mainly from granitic or schistose rocks, or from a mixture of the two in some approximately definite proportion. It was also shown that the shape of the particles as originally derived from their parent rock is sufficiently definite and characteristic to enable us to form a very good opinion respecting the amount of subsequent mechanical or other change.

"Applying these principles to the study of particular cases, it was shown that the coarser British sandstones have been mainly derived from granite rocks somewhat intermediate in character between those of the Scotch Highlands and Scandinavia. Some of them consist of grains which have undergone scarcely any wearing, and are as angular as those derived directly from decomposed granite, unlike the blown sands of the deserts, which are worn into perfectly rounded grains.

"The finer sands are no less angular than the coarse. They are not derived from the wearing down of larger fragments, but have resulted from the

separation of the small from the large grains by the action of currents. Some fine-grained sandstones have been mainly derived from granitic rocks, but on the whole, the small particles of quartz have more commonly been derived from the breaking up of schistose rocks. Clays and shales consist to a great extent of particles identical in all their characters with those derived from the decomposition of felspars and other minerals which undergo a similar change. As a general rule we meet with many grains of sand even in clays chiefly consisting of extremely minute granules, which can easily be explained by the remarkable manner in which such material, when suspended in water, collects into small compound grains, which subside at a rate quite independent of what would be the velocity of subsidence of the separate particles if they were detached.

"The conclusions derived from a study of the characters of the separate grains are confirmed by the occurrence of what may be truly considered to be grains of granite or mica schist. We also in some cases meet with grains sufficiently large to show the characteristic structure of the still more complex rocks of which they are composed. Thin sections of some of the oldest slates in Wales are thus, as it were, a perfect museum of specimens of the rocks existing at a still earlier period, broken up and worn down into the sands which formed these very ancient slates."

The Corallian Rocks of England.—On the 10th of January last the Rev. J. F. Blake and Mr. W. H. Hudleston communicated to the Geological Society a most important paper on the Corallian Rocks of England, describing in great detail the series of deposits existing betwixt the Oxford and Kimmeridge Clays. Topographically the Corallian region is divided into five districts of very unequal size, wholly separated from each other. In the Weymouth district (I.) one section discloses 230 feet of beds between the Oxford and Kimmeridge Clays, made up in ascending order of grits, clays, marls, and oolites, gritty limestones very fossiliferous towards the top, clays and grits. Another section on the opposite side of the anticlinal shows the same development of the central limestones; but the lower series is considerably attenuated. There are hardly any corals; argillaceous and arenaceous matter, always, however, more or less mixed with lime, preponderates; but there is a rich and varied fauna, which has strong affinities with that of some of the Coralline beds of other districts. This culminates in the *Trigonia* beds, which lie towards the top of the main limestone series; above this the fauna inclines to Kimmeridgian, below to Oxfordian types. The remarkable character of the Supra-Coralline beds was noted, especial reference being made to the mineral constitution, fossil contents, and geological position of the Abbotsbury iron-ore. In the North Dorset district (II.) the thickness of the mass is much reduced, and its constitution greatly altered. Corals are still very rare, but calcareous sediment greatly preponderates, and is made up largely of comminuted shells, loosely aggregated pisolites, and rubble frequently false bedded; the arenaceous base of the Corallian series, described generally under the term Lower Calcareous Grit, is almost at its minimum in the neighbourhood of Sturminster. The central limestones contain a moderate assemblage of the usual Coralline forms, but *Cidaris florigemma* appears confined to a rubbly bed about 8 feet thick. The West Midland range (III.), extending from Westbury to Oxford, exhibits

the greatest variety, and, being classic ground, contains a larger proportion of the type forms of the rocks. The development is very unequal, and the entire group is reduced to less than 25 feet in some places; but where the sandy base is expanded, as in those districts where the escarpment faces the north, the thickness exceeds 100 feet, occasionally falling to about 30 feet in the direction of the dip, with the probability of the entire mass ultimately thinning to a feather edge. In many places true Coral Rag is largely developed, usually terminating the Corallian series in an upward direction, or at most succeeded by a very few feet of ferruginous sand. Throughout the great escarpment facing the upper valley of the Thames the lower arenaceous member predominates, though much mixed with thin-bedded sandy clays, the whole constituting a loose formation, which is capped by hard gritty limestone containing an abundant fauna. representative of the middle series, differing somewhat, on the one hand, from the Rag, with its partially Kimmeridgian character, and, on the other, from the Lower Calcareous Grit, whose affinities are, of course, Oxfordian. The beds of this district, however, are exceedingly varied. District IV. includes the Coral reef at Upware, 75 miles E.N.E. of Oxford; though the exposures are small, they are very suggestive. The limestone of the south pit is an excellent Coral Rag, but softer and more chalky than much of the Coral Rag of the West Midland district. Moreover, whilst the rock contains many familiar forms, and especially *Cidaris florigemma*, whose presence in abundance invariably indicates a distinct horizon, we also find the casts of shells, rarely or never met with in the West of England, but which appear common in some parts of the Continent, *e.g.* species of *Isoarca*, and certain species of *Opis*, which latter occur also in a portion of the Yorkshire Basin (V.) This bears 130 miles N. by W. from the reef at Upware. The Corallian beds are grouped as a belt of rocks enclosing an oval tract of Kimmeridge Clay. There is more symmetry here than in the south, and the triple division of grit, limestone, and grit, though not absolutely true in all places, is fairly accurate; most of the beds are better developed, and the contrast between the Coral Rag and underlying Oolites is strongly marked. In the Tabular Hills these Oolites constitute a double series, divided by a "Middle Calc Grit," a fact first indicated on stratigraphical grounds by Mr. Fox Strangways, and amply borne out by fossil contents. The shell beds of the Lower Limestones are, especially in their lower parts, charged with Brachiopoda and other forms of the Lower Calc Grit; whilst the Upper Oolite, on which the Coral Rag reposes, contains a far more varied fauna, though singularly destitute of Brachiopoda. The fauna of the Rag here, as elsewhere, inclines to Kimmeridgian types. In conclusion it was shown that, since the leading feature of the rock masses between the Oxford and Kimmeridge Clays is *variety*, a strict and rigid correlation is altogether impossible. Yet in spite of great local differences, producing in many places a strangely contrasted facies, there are certain features which may be deemed fairly characteristic of the several divisions. The bank-like character of most of these beds is very striking.

Possible displacement of the Earth's Axis.—In connection with certain well-known geological and especially palæontological phenomena, there has long been a growing belief among naturalists that some means must be found of explaining a change in the position of various parts of the earth's

surface relatively to the plane of the ecliptic and consequently to the great source of light and heat, the sun. The Rev. J. F. Twisden has lately communicated to the Geological Society a valuable paper connected with this subject, its purpose being, as he describes it, the discussion of the possibility of a displacement of the earth's axis of figure under the conditions indicated in a question (suggesting the possibility of a displacement of the axis of figure from the axis of rotation amounting to 15° or 20°) put to mathematicians in a passage of the Anniversary Address delivered to the Geological Society by its president, J. Evans, Esq., on February 18, 1876. Mr. Evans suggested that the occurrence of a great elevation at some part of the earth's surface might affect the geographical position of its poles. The treatment of the question is kinematical; the forces by which the elevations and depressions might be effected do not come under discussion. In determining numerically the amount of the deviation from the formulas investigated, approximate numbers seem to be sufficiently exact for every useful purpose. The conclusions arrived at are as follows:—

1. The displacement of the earth's axis of figure from the axis of rotation that would be effected by the elevations and depressions suggested in the question above referred to would be less than 10° of angle.

2. A displacement of as much as 20° could be effected by elevations and depressions of the kind suggested only if their heights and depths exceeded by many times the height of the highest mountains.

3. Under no circumstances could a displacement of 20° be effected by a transfer of matter of less amount than about a sixth part of the whole equatorial bulge.

4. Even if a transfer of this quantity of matter were to take place, it need not produce any effect, or only a small effect, on the position of the axis of figure, *e.g.* if it took place in a way resembling that suggested in the question, it would produce a displacement amounting to but a small part of 20°.

5. If, however, we suppose a deviation of the axis of figure from the axis of rotation amounting to as much as 20° to have been by any means brought about, the effect would be to cause a sort of tidal motion in the ocean, the greatest height of which would tend to be about twice the depth of the ocean. The author suggests as probable that the effect of this tendency would be to cause the ocean to sweep over the continents in much the same way that a rising tide sweeps over a low bank on a level shore.

6. The notion that a large deviation of the earth's axis of figure from its axis of revolution may be effected by elevations and accompanying depressions is at first sight an inviting way of bringing polar lands into lower latitudes, and thereby accounting for the more genial climate that is believed to have once prevailed in such countries as Greenland. The investigation by which the above results have been obtained seems to show that the desired explanation is not to be sought in the direction indicated by Mr. Evans's question. Whether there is any other agency by which a gradual displacement of the pole geographically could be effected is a question of far wider scope than that discussed in the present paper, and one which the author does not profess to determine.

The Rocky Mountains in Colorado.—Dr. A. C. Peale discusses ("Silliman's Journal," March, 1877) the geological phenomena of the Rocky Moun-

tain region of Colorado, and comes to the following conclusions as to their chronology. In very early times there was in Colorado, Archæan land rising above the Palæozoic sea. As the Carboniferous age progressed this land diminished by encroachments of the sea, due to subsidence of the land, which persisted through the Triassic, Jurassic, and Cretaceous periods into the early Tertiary. At the close of the Lignitic Tertiary period, there was a physical break, followed, at least locally, by a subsidence and subsequently by an elevation after the deposition of the Miocene strata. The elevation of the Rocky Mountains as now seen in Colorado is the result of an elevation commencing in early Tertiary time, when there was probably great volcanic activity in the region, and continuing through the Tertiary period, accelerated perhaps at the close of the Lignitic, and after the deposition of the Lower Miocene strata. Dr. Peale thinks that this elevation is still going on. The great elevation ascribed to the Colorado region in Palæozoic times is considered by Dr. Peale to be confirmatory of the generalization of Dr. Newberry, to the effect that the outlines of the western part of the North American continent were already indicated at that early period in the history of the earth.

A New Algerian Fossil Hippopotamus.—According to M. Gaudry ("Bull. Soc. Géol. de France," February, 1877), the remains of a new and interesting species of *Hippopotamus* occur in a breccia at Bone, in Algeria. The fossil bones indicate a species in which the dentition is less different from that of the pig type than that of the ordinary *Hippopotami.* It differs from the existing Hippopotamus (*H. amphibius*) by the presence of six incisors instead of four in the lower jaw, the nearly equal size of the incisors, the thicker, unchannelled, and more clearly marked enamel of these teeth, and the presence of only fine striæ, instead of strong channels, in the canines. By the number of incisors the Hippopotamus from Bone would belong to the genus *Hexaprotodon* of Falconer and Cautley, which is represented by three Indian species (*H. sivalensis, iravaticus,* and *namadicus*); but, from the fact that the teeth of the Algerian species present certain peculiarities not noticed by Falconer in those of the eastern deposits, M. Gaudry regards the former as a distinct species under the name of *Hippopotamus* (*Hexaprotodon*) *hipponensis.* M. Pomel thinks that the deposit in which these remains occur is of Quaternary age.

Hydractinia, Parkeria, and Stromatopora.—Mr. H. J. Carter publishes in the "Annals and Magazine of Natural History" for January, an elaborate paper, the object of which is to prove that the curious fossils forming the genera *Parkeria* and *Stromatopora,* and probably some others, are really the remains of Hydrozoa allied to *Hydractinia.* He indicates the characters of the *Hydractiniæ,* and describes a new calcareous form, *H. calcarea,* from the Guinea coast, where it is found incrusting small univalve shells tenanted by hermit crabs, and indicates its close approach to the species (*H. pliocena*) described in 1872 by Professor Allman from the Coralline Crag of Suffolk. He also describes a species with a siliceous skeleton (*H. Vicaryi*) from the Upper Greensand of Haldon Hill. The *Parkeriæ,* spherical or spheroidal bodies found in the Cambridge Greensand, have been described by Dr. Carpenter as Foraminifera, on the ground of their chambered structure, which starts, as in many Foraminifera, from a peculiarly chambered nucleus.

Mr. Carter maintains that the structure of the spherical coats is identical with that of the Hydractiniæ, and that the central chambered core is probably a Foraminifer on which the first incrusting growth of the *Parkeria* took place. *Loftusia*, a singular melon-shaped fossil from the Nummulitic formation of Persia, closely resembles *Parkeria* in general characters, and if the latter is to be transferred to the Hydrozoa, *Loftusia* must go with it; and Mr. Carter considers that with the assistance of a new form which he describes here under the name of *Bradya tergestina* from the Lower Chalk, the early palæozoic *Stromatoporæ*, the position of which has always been doubtful, may be brought under the same category.

Supposed Radiolaria in Carboniferous Limestones.—According to a report in "Nature," March, 22, 1877, Mr. J. D. Siddall has discovered remains of Radiolarians in the Halkin and Minera limestones. Some polished blocks of these limestones are said to show specimens of Radiolaria, beautifully preserved, and representing most of the types to be seen in the Barbadoes earth. The identification of these objects is, however, we believe still doubtful.

A New Fossil Sponge.—Mr. W. J. Sollas has described before the Geological Society a very interesting fossil sponge from the Cambridge Coprolite beds. He regards it as belonging to the group named Holorhaphidota by Mr. Carter, in which the skeleton consists entirely of siliceous spicules, united to form fibres, and describes it as characterized by the possession of an irregularly reticulate fibrous skeleton of this kind, composed of acerate spicules lying parallel to each other and to the sides of the fibre. Although these spicules are still sufficiently well preserved to be figured and measured individually, and the author is of opinion from the structure of the sponge that they were originally siliceous, they now consist of calcareous material. He indicates that a similar replacement has occurred in the case of various sponges of the genera *Manon* and *Porospongia*; and that this fact is of much interest as getting rid of the necessity of establishing for these forms a peculiar order of Calcispongiæ, composed exclusively of anomalous extinct forms resembling in structure existing siliceous types. The new fossil sponge is described under the name of *Pharetrospongia Strahani*. Some doubts are expressed by Fellows of the Society as to the supposed replacement of silica by carbonate of lime.

METEOROLOGY.

The Alveoliform Depressions in Meteorites.—M. Daubrée notices the peculiar depressions often observed on the surface of meteorites, which have been compared to the impressions left by the finger upon a soft paste. Such impressions occur in all sorts of meteorites. It has been supposed that these depressions are due to a bursting process occurring at the surface of the meteorites when suddenly heated on entering the earth's atmosphere, but none of the experiments made to test this supposition have confirmed it. M. Daubrée says that the large, imperfectly burnt grains of gunpowder which often fall in front of the mouths of cannon, present alveoliform depressions perfectly similar in form to those of meteorites. From direct experi-

ments it appears that these cavities in the grains of powder are due to the gases developed at the moment of ignition, which burst in various directions under very high pressure. This fact has been demonstrated experimentally by the mode in which the gases of gunpowder, under a pressure of almost a thousand atmospheres, act upon spheroids of zinc submitted to them. In the same way, when meteorites enter our atmosphere with the enormous velocity of 20 to 30 kilometres per second, they are subjected to very great pressure, producing energetic gyratory movements. Whirling in this way under great pressure the air tends to act like a screw-tap, and this mechanical action is in general accompanied and reinforced by the chemical action due to the combustible nature of the meteoritic rocks at high temperatures.—*Bull. Soc. Géol. de France*, February, 1877.

Parhelion at Campan.—One of those phenomena which, in more superstitious ages, would have set all that witnessed it in a state of alarm, was observed by M. Soucaze at Campan, in France, on February 5 last. The sun, at one o'clock was surrounded by an immense luminous circle, occupying about 50 degrees. At the rising and setting of the sun, when it was at about the same height above the horizon, this circle contained two exactly similar luminous points, each about three times the apparent volume of the sun, and exhibiting a sort of tail like that of a comet on the side opposite to the sun. The light of the circle was white and faint; the two mock suns displayed all the colours of the rainbow, which extended also over the whole of the tails.—*Comptes rendus*, March 5, 1877.

Great American Meteor.—On the evening of Thursday, 21st December, 1876, according to a notice in "Silliman's Journal," February, 1877, a meteor of unusual size and brilliancy passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio. Professor Newton regards it as worthy of special record in many respects, and gives the best account of it that he could compile from newspaper reports and letters. The meteor appears to have been first seen over the State of Kansas, probably as far west as the centre of the State. It passed nearly over, and probably south of the cities of Topeka and Leavenworth, when it was at an altitude of about sixty miles. Over the centre of the State of Missouri one or more explosions occurred; and shortly after crossing the Mississippi, which it did between Hannibal and Keokuk, but nearer to the former place, the meteor broke into several fragments. This breaking up continued while it was crossing the States of Illinois, Indiana, and Ohio. A loud explosion occurred as far east as Concord and Erie; in fact, according to Professor Newton, the meteor consisted of a large flock of brilliant balls chasing each other across the sky, the number being variously estimated at from 20 to 100. This flight is of peculiar interest, on account of the long continued violent disintegration. The region round Chicago was overcast, and though the clouds were remarkably illuminated, the meteor itself was not seen, nor were any sounds heard there. From St. Louis no sound is reported. But over all the centre of Illinois, between those two cities, a terrific series of explosions occurred. The sound was also heard at Keokuk, in Iowa, but apparently not elsewhere in that State. Over the northern part of Indiana the passage of the meteor was followed by loud explosions, and a rumbling was heard as far south as Bloomington, but whether due to the meteor is uncertain. Whether a

portion of the body pursued its way onward over the State of New York and out of the earth's atmosphere seems doubtful. Its path was nearly parallel to the surface of the earth, and might easily be upward in its latter part. But if the sky was then clear over western New York, the meteor would in such case certainly have been seen in that region. The path was N. 75° E., and nearly or quite a straight line, not less than 1,000 miles long. The duration of flight was variously estimated from fifteen seconds up to three minutes, but of course no one saw the body through more than a fraction of its path. It entered the air in a course differing only about 30° from the earth's motion, and was overtaking the earth. Its real motion therefore made a still smaller angle with that of the earth, but the relative velocity was so slow, probably not more than ten or fifteen miles per second, that the earth's attraction must have changed its direction greatly. Previous to the change it must have been coming from a point near and a little south of the ecliptic, in the eastern or southern part of the constellation Copernicus, but there appears to be no known meteor radiant at that time near that part of the heavens. According to the "Western Review" (February, 1877), the meteor was first observed at Hays City, Kansas, passing slowly along at an altitude of about 25 degrees above the horizon. In passing over Kansas City (Missouri), it is said to have appeared "about as large as the full moon, with a train from 25 to 100 feet long, of a reddish or orange colour, and entirely unattended with any noise or sound."

MINERALOGY.

Native Metallic Iron from Brazil.—M. A. Damour has communicated to the French Academy of Sciences (*Comptes rendus*, March 12, 1877) a notice of a native metallic iron from Santa Catharina, in Brazil, which is supposed to be of meteoric origin. The mass resembles wrought iron in appearance, can be worked with the file, and, although malleable, breaks easily when strongly bent. Its fracture is fine grained, and shows an appearance like stratification in some parts. A polished surface, when treated with acid, showed Widmanstätten's figures. Its filings, when moistened and exposed to the air, do not oxydize. The specific gravity of various fragments was found to be 7·747, 7·825, and 7·836. M. Damour describes the process of analysis to which he subjected this substance, and gives the following as the result:—

Iron	0·6369
Nickel	0·3397
Cobalt	0·0148
Sulphur	0·0016
Phosphorus	0·0005
Carbon	0·0020
Silicium	0·0001
Total .	0·9956

The proportions of carbon and silicium are therefore very nearly the same as are found in the best samples of iron; and the amount of nickel is very

much greater than that met with in any known meteoric iron. To the presence of this great proportion of nickel M. Damour attributes the resistance of this iron to oxydation, and to the action of dilute sulphuric and hydrochloric acids.

In confirmation of this opinion, M. Boussingault stated that he had found that alloys of steel with 5, 10, and 15 per cent. of nickel, rather seemed to favour oxydation, and that he had seen the filings of meteoric irons containing from 5 to 7 per cent. of nickel rust very quickly under the joint action of air and moisture. But since the examination of the iron from Santa Catharina, he had prepared in his laboratory an alloy of 62 per cent. of steel with 38 per cent. of pure nickel, and found that neither the filed face of the ingot nor the filings from it ever rusted by contact with air and water.

From a statement by M. Daubrée, it appears that this native iron is exceedingly abundant in the province of Santa Catharina, where it is worked to a considerable extent, several thousand kilogrammes having been already extracted. He describes its constitution as exceedingly curious. Besides the metallic iron, it contains particles and slender veins of pyrrhotine, or magnetic pyrites, which, when dissolved in acid, leaves, besides sulphur, a black residue in little crystalline laminæ, which proved to be graphite. The surface of the mass is covered with a black crust of magnetite, and the same mineral in many cases separates the pyrrhotine from the grey iron. The origin of the masses is doubtful; but, as M. Daubrée remarks, their chemical and mineralogical characters have never yet been observed in any authentic meteoric iron.

Telluride of Gold, a new Mineral.—A pure crystalline telluride of gold has been lately discovered at Nagyáz in Hungary. It was exhibited by Professor Krenner at a recent meeting of the Hungarian Geological Society, and the name of *Bunsenite* was proposed for it.

Supposed Organic Enclosures in Quartz.—Pastor Kawall has communicated to the Imperial Society of Naturalists in Moscow ("Bulletin," 1876, No. 3), an account of the occurrence of organisms enclosed in rock-crystal. In a specimen from Ufalei, in Siberia, he found a pale green naked caterpillar with a dark head, 1·7 millim. in length, and 0·3 millim. in thickness. He regards it as probably the larva of a Tineid moth, and proposes to name it provisionally *Tineites crystalli*. Above this larva is a smaller and more contracted one, only 0·7 millim. in length. Another surface shows a third, bent caterpillar, and to the left of this two smaller ones. Besides these there were some half-dozen of small larvæ, and many brownish and greenish fragments, some of which probably represent the excrement of the caterpillars. In another crystal he finds filamentous enclosures, probably representing confervæ.

PHYSICS.

Sensitive Flames.—A new form of burner for the production of sensitive flames is described by Mr. R. H. Ridout ("Nature," xv. 119). It has the advantage of giving a very sensitive flame at very low pressures. It consists of a glass or metal tube about five inches long and five-eighths of an inch in diameter, closed at one end by a perforated cork, through which slides a piece of glass tube one-eighth of an inch in diameter, and about six inches long. One end of the smaller tube is drawn out in the blow-pipe to form a jet with an aperture of about $\frac{1}{16}$ inch; the other end is connected with the supply of gas. The larger tube being then fixed in a support, the smaller one is pushed up into it through the perforated cork, until the jet aperture is nearly level with the mouth of the larger tube; and on a light being applied, it gives a long steady flame, which is rendered sensitive by lowering the smaller tube.

By an ingenious arrangement the same gentleman has arrived at some interesting results with regard to the influence of combustion on the pressure of gas in tubes. Two parallel vertical tubes are connected by a horizontal tube containing a drop of water as an index of pressure. When gas is allowed to flow through both tubes, and one of the jets is lighted, the water moves towards the other, showing that the effect of the combustion is to obstruct the flow. A sensitive flame was found to produce greater resistance when shortened by a noise or a musical note, but this effect is produced even when the jet is not lighted.

Singing Tubes.—M. A. G. Montenot lately exhibited to the French Society for the Encouragement of Industrial Arts some experiments on metallic tubes which produce sounds when a source of heat is placed within them in a particular nodal position. A copper tube, into which a piece of metallic web, heated to redness, was introduced, produced an intense sound. Into another tube a little furnace, containing incandescent charcoal, was put, and this also produced a musical sound, which was modified according to the position occupied in the tube by the source of heat, and the length of the tube. M. Montenot regards this experiment as particularly interesting, not only from a theoretical point of view, as introducing a new element into the investigation of the cause of the sound produced by singing flames, but also because it may admit of industrial application in the production of sounds of sufficient intensity to be heard at great distances, as fog-signals on dangerous coasts.—*Les Mondes*, February 15, 1877.

A Gigantic Induction Coil.—Mr. Apps has lately constructed for Mr. W. Spottiswoode the largest induction coil yet made. It is described by Mr. Spottiswoode in the "Philosophical Magazine" for January. It has two primaries. That used for long sparks has a core consisting of a bundle of iron wires ·032 inch thick, which form a solid cylinder 44 inches long, and 3·5625 inches in diameter, and weighing 67 pounds. The copper wire of this primary is 660 yards long, and ·096 inch thick; it has a conductivity of ·93, and a total resistance of 2·3 ohms. It contains 1,344 turns, wound singly in six layers; its total length is 42 inches, its internal diameter 3·75 inches, and its external diameter 4·75 inches. The second primary, to be used with batteries of less resistance for short thick sparks, and for spectroscopic purposes, has

a core weighing 92 pounds, and 84 pounds of wire. The latter may be so connected as to be equivalent to a wire of double or six times the cross section of a single wire. The secondary coil consists of 280 miles of wire arranged in 341,850 turns, and forms a cylinder 37·5 inches long; its internal and external diameters are respectively 9·5 and 20 inches. The total resistance is 110,200 ohms. It is wound in four sections, the diameter of the wire in the two central sections being ·0095, and in the outer ·0115 and ·0110 inch. The increased section of the extremities is to allow for the accumulated charge that portion of the wire has to carry. A condenser of the size commonly employed with a 10-inch coil was found to give the best results. It consisted of 126 sheets of tin foil, 18 by 8·25 inches, separated by two thicknesses of varnished paper ·0055 inch thick. With five quart Grove cells a spark of 28 inches was obtained; 10 cells gave one of 35 inches, and 30 one of 37·5, and afterwards of 42 inches. These sparks were obtained without any difficulty. With the 28-inch spark a block of flint glass three inches thick was pierced. In vacuum tubes this coil produces illumination of great brilliancy and long duration; with from 20 to 30 cells, and a slow mercury break, the striæ last long enough to enable their forward and backward motion to be perceived directly by the eye. The appearance of the striæ, when viewed in a revolving mirror, was remarkably vivid, even when only two or three cells were employed.

Evolution of Hydrogen at both Electrodes.—According to Dr. Elsässer ("Bericht Berl. Chem. Gesellsch," January 1877), if a magnesium wire be made the anode in a decomposition-cell containing very dilute sulphuric acid, with a platinum wire as the cathode, hydrogen gas is evolved at both electrodes, though only half as much is produced at the anode as at the cathode, whatever may be the strength of the current employed. A moderately dilute solution of magnesium sulphate gives the same result, but in this case magnesium hydrate is deposited at both electrodes. The quantity of the magnesium dissolved at the anode was found to correspond exactly to the amount of hydrogen set free there, the volume of hydrogen evolved at the cathode being the same as that set free in a voltameter in the same circuit. The author believes that the positivity of the magnesium is so increased by the current that it combines not only with the oxygen set free by the current, but also with additional oxygen, thus setting free the hydrogen which was combined with the latter. He is, however, unable to explain why the amount of hydrogen thus evolved should be exactly half that produced at the cathode.—*Silliman's Journal*, March 1877.

New Deep Sea Sounding Apparatus.—M. C. Tardieu has communicated to the French Academy of Sciences the description of a new sounding apparatus invented by him. The apparatus consists of a hollow sphere of india-rubber, several centimetres in thickness, communicating with an iron reservoir, by means of a narrow tube furnished with a valve. The india-rubber sphere being filled with mercury, any increase of pressure forces into the iron reservoir a certain quantity of mercury, the return of which is prevented by the valve. When this apparatus is let down into deep water the weight of the mercury in the reservoir will serve as an indication of the pressure to which it has been subjected, and consequently of the depth attained.—*Comptes rendus*, 5 February, 1877.

PHYSIOLOGY.

The Phenomena of Digestion in the Stomach.—M. C. Richet has had an opportunity of renewing the direct observations made in America many years ago by Dr. Beaumont upon the action of the stomach. A boy, suffering from an impassable constriction of the œsophagus, was operated upon by Professor Verneuil, who performed upon him the dangerous operation of gastrotomy. The operation was successful, and established a permanent opening into the stomach, through a sound placed in which the necessary food was administered to the patient. In some respects the case was particularly important, as the complete impermeability of the œsophagus prevented any admixture of saliva with the gastric juices. M. Richet found that the stay of the food in the stomach was rather variable, but it was generally from three to four hours in the case of ordinary food, such as starchy materials, fats, and meat. With milk the stomachal digestion lasted from an hour and a half to two hours; the absorption of water and alcohol was much more rapid, as no traces of them were to be found in from thirty-five to forty-five minutes. The food does not gradually disappear from the stomach, but apparently it passes through the pylorus almost, as the author says, *en bloc.* During the first three hours of digestion the volume of the mass of food is unchanged; then, within a quarter of an hour at the utmost, the whole has passed away. Hunger is not caused simply by emptiness of the stomach; the organ is generally empty in four hours after a meal, but the sense of hunger is not felt until the lapse of about six hours.

To obtain pure gastric juice, M. Richet first washed out the stomach several times with distilled water, and then gave the unfortunate boy something tasty to chew, when by a reflex action the secretion of gastric juice was pretty abundantly produced. The average acidity of the gastric juice, whether pure or mixed with food, was found to be equivalent to 1·7 grains of hydrochloric acid per 1,000 grammes of liquid. It varied from 0·5 to 3·2 grains. Wine and alcohol increase the acidity; cane sugar diminishes it. When acid or alkaline liquids are injected into the stomach its fluids tend rapidly to resume their normal acidity, the latter being attained in about an hour. The gastric juice is more acid while digestion is going on, and the acidity increases slightly towards the end of the operation.—*Comptes rendus de l'Acad. des Sci.*, March 5, 1877.

ZOOLOGY.

Protective Mimicry in Bats.—Dr. Archer has noticed that a Brazilian bat (*Rhynchonycteris naso*) presents an example of protective mimicry, inasmuch as, during repose, it hangs from the branches of trees with its wings extended, so as easily to escape notice among the leaves. Dr. Dobson, in a letter to "Nature" (February 22), in reply to that of Dr. Archer, indicates other instances of mimicry in the same order of mammals. Thus *Kerivoula picta*, *Vespertilio formosus* and *V. Welwitschii*, although differing in several respects, and inhabiting widely separated regions, exhibit a

very similar coloration, the fur of the body being of some shade of orange-brown, whilst the wings are variegated with orange and black. The grounds for regarding this coloration as an instance of protective mimicry may be seen from the following quotation from a paper by Mr. Swinhoe. He says:—"A species of *Kerivoula* allied to *K. picta* and *K. formosa*, was brought to me by a native. The body of this bat was of an orange-brown; but the wings were painted with orange-yellow and black. It was caught, suspended head downwards, on a cluster of the round fruit of the Longan-tree (*Nephelium longanum*). Now this tree is an evergreen; and all the year through some portion of its foliage is undergoing decay, the particular leaves being, in such a stage, partially orange and black. This bat can, therefore, at all seasons, suspend from its branches, and elude its enemies by its resemblance to the leaf of the tree. It was in August when this specimen was brought to me. It had at that season found the fruit ripe and reddish-yellow, and had tried to escape observation in the semblance of its own tints to those of the fruit." With regard to the great Frugivorous bats of the genus *Pteropus*, which measure nearly a foot long, with an expanse of wing between four and five feet, Dr. Dobson says:—"Anyone who has seen a colony of these bats suspended from the branches of a banyan-tree, or from a silk cotton-tree (*Eriodendron orientale*), must have been struck with their resemblance to large ripe fruits, and this is especially noticeable when they hang in clusters from the leaf-stalks of the cocoa-nut palm, where they may be easily mistaken for a bunch of ripe cocoa-nuts. Hanging close together, each with his head bent forwards on the chest, his body wrapped up in the ample folds of the large wings, and the back turned outwards, the brightly coloured head and neck is presented to view, and resembles the extremity of a ripe cocoa-nut, with which this animal also closely corresponds in size." Of the smaller Frugivorous bats of the genera *Cynopterus* and *Macroglossus*, which feed on the fruit of guavas, plantains and mangoes, Dr. Dobson remarks that they "resemble these fruits closely in the yellow colour of their fur and in their size, so that it is very difficult to detect one of these bats when suspended among the leaves of any of these trees," but he is not prepared to maintain that these are examples of "protective mimicry."

The Nest of the Aye-Aye.—According to MM. A. Milne-Edwards and Grandidier, that curious quadrumanous mammal the Aye-Aye (*Chiromys madagascariensis*) constructs a large globular nest. A specimen procured by M. Soumagne, honorary French consul in Madagascar, and sent by him to Paris, is described as being made with much care and art at the fork of several branches of a large Dicotyledonous tree. Its outer surface is formed of large rolled-up leaves of the *Ravinala* (or travellers' tree), serving as an impermeable covering for the interior, which contains an accumulation of small twigs and leaves. The narrow aperture is placed on one side. In this respect, as MM. Milne-Edwards and Grandidier remark, the Aye-Aye resembles the lower members of the order Lemurina (such as *Lepilemur*, *Chirogaleus*, and especially *Microcebus*), which bring up their young either in holes of trees or in true nests. The nest of *Microcebus myoxinus* is described as resembling on a small scale that of a crow, being composed of small twigs interlaced, with a depression lined with hairs in the centre, in which the young repose.—*Comptes rendus*, January 22, 1877.

The Nest of the Gourami.—M. Carbonnier has studied and described the habits of several species of fishes belonging to the curious group of the Labyrinthici, the "Pharyngiens labyrinthiformes" of Cuvier, so called from the singular structure of their pharyngeal bones, which constitute on each side a labyrinthic cavity for the reception of water, serving to moisten the gills when the fish is out of its native element. The Climbing Perch (*Anabas scandens*) of India is perhaps the most generally known species of this group, but the most important one is the Gourami (*Osphromenus olfax*), an inhabitant of the fresh waters of China and India, which grows to a large size, and is highly esteemed for the excellence of its flesh. The history of its nidification, as told by M. Carbonnier, is very curious. As in the case of most if not all nest-building fishes, the labour falls to the lot of the male. M. Carbonnier placed his gouramis in an aquarium containing about 48 gallons of water, which he kept at a temperature of 77° Fahr. In a few days the bodies of the males displayed brilliant colours, and they began to pursue each other, and struggled furiously for the regards of the females. Having selected the finest male, M. Carbonnier left him in the aquarium with a female into whose good graces he seemed particularly anxious to insinuate himself. He soon commenced in one of the corners of the aquarium the formation of a frothy nest, which in a few hours was 6 or 7 in. in diameter and 4 or 5 in. high. He then rose to the surface of the water, and drawing in a supply of air, gradually emitted it in the form of bubbles, englobed by the mucous secretion of the mouth; these bubbles he collected and carried into his nest. The nest being completed, the male watched by it patiently, and whenever the female approached he displayed his brilliant colours, until at last he seized her and caused her to perform a first spawning, and these operations were repeated until all the eggs were laid. In order to raise these into the floating nest the male now adopted a singular device. Rising to the surface, he took in an abundant supply of air, and then, descending, he placed himself well below the eggs, and suddenly, by a violent contraction of the muscles of the mouth and pharynx, drove the air contained in them out through the branchial apertures, from which it issued so divided by passing among the lamellæ and fringes of the gills, that it formed two jets of a regular gaseous dust which enveloped the eggs and carried them up towards the surface. After the operation the male gourami himself looked as if he had been sprinkled with thousands of minute pearls. The number of eggs produced was estimated by M. Carbonnier at between two and three thousand, but only about six hundred of them hatched. For three days the young fishes resemble globular tadpoles, but within six days after hatching their development is completed. Then commence the paternal troubles of the male, for the young fishes, with the conceit and heedlessness natural to their time of life, immediately begin escaping from the shelter of their nest. The male, however, pursues them and drives them back by means of jets of air-bubbles, and it is not until about ten days after hatching that they are left to wander at their own will and pleasure. M. Carbonnier states that he has 520 young gouramis which were hatched in his aquarium in July last, and which at the beginning of December were from $1\frac{1}{4}$ to $2\frac{1}{2}$ in. long. He seems to hint at the possibility of acclimatizing the fish in Europe, and remarks that, among

other advantages, it possesses the faculty of spawning several times in the year.—*Comptes rendus*, December 4, 1876.

Digestive Organs of the Phalangida.—M. Félix Plateau describes these organs as follows:—The digestive tube consists of a short œsophagus, followed by an immense median sac, into which open dorsally about thirty voluminous cæca, which occupy nearly all the cavity of the body; and lastly, of a short terminal intestine, which receives the malpighian tubes. The cæca opening into the middle intestine are identified by M. Plateau with the voluminous organ commonly called the liver in the true spiders, and not, in accordance with the opinions of previous writers, with the cæca at the hinder part of the sucking œsophagus of those animals. He also holds that the denomination *liver* cannot properly be applied to these organs, either in the arachnida or in the crustacea, but that their office is the secretion of the principal digestive fluid.—*Ann. and Mag. Nat. Hist.*, March, 1877.

Development of Tænia inermis. — The prevalence of *Tænia inermis* at Montpellier, Cette, and Marseilles, led MM. Massé and Pourquier to endeavour to ascertain the history of that tapeworm. They administered numerous segments of the worm to two lambs, and a calf, a rabbit, and a dog. The lambs, the rabbit, and the dog did not appear to suffer from the experiment; and when killed and examined at the end of about seven weeks, no traces of cysticerci could be found in them. The calf, on the contrary, showed symptoms of inconvenience in about a fortnight, and these increased until, two months after the administration of the joints of the tapeworm, he was in a condition that showed he could not long survive. On examining the tongue, there was found near its base on the left side a swelling about the size of a small haricot bean, under the mucous membrane. The animal was then killed, and about forty cysticerci were found in the muscles of various parts of the body, but none in the heart, brain, liver, or any of the other viscera. The cyst first observed on the tongue was nearly three-fifths of an inch long; those of the muscles were only about half this size. The cysts were clear, and allowed the heads of the future *Tæniæ* to be recognised within them; these presented the characters of *Tænia inermis*. These experiments confirm the results obtained by Leuckart, Cobbold, Enock, and Saint-Cyr, and the author supposes that it is to the importation of cattle from Africa that the prevalence of *Tænia inermis* on the Mediterranean coasts is to be ascribed. The existence of the cysticercus in the living animal may be recognised by the presence of small tumours under the tongue.—*Les Mondes*, December 28, 1876.

Podophrya fixa motile.—A communication made by M. E. Maupas to the French Academy of Sciences (*Comptes rendus*, November 13, 1876) will be interesting to microscopists. He finds that *Podophrya fixa* belies its name, and can at pleasure pass from a fixed to a motile state and *vice versâ*; in fact, as he says, it is the most vagabond of Acinetina. Whether free or fixed, the author says, the body of the *Podophrya* is always nearly or quite spherical, with the suckers distributed pretty regularly over the whole surface, except on a small peripheral region corresponding to the part where the contractile vesicle is situated. After watching some of them for a time, M. Maupas saw the suckers slowly retracted into the body, whilst at the same time the

suckerless part became depressed, forming a furrow which eventually gave the body a reniform appearance. The surface of the groove showed what appeared to be striæ, but these were resolved by a high power into rows of little points which increased rapidly; the furrow spread so as to form a ring round the body, and its points became converted into long thin cilia which began to oscillate gently. The suckers had then entirely disappeared, and after a time the body was flattened in a direction vertical to the ciliated belt, the cilia became more active, and the *Podophrya* moved through the water, turning upon itself, but with the part where the furrow originally appeared always in front. All these changes took place in about half an hour. The period of activity varies in length, and in returning to the motionless condition the *Podophrya* passes through a series of changes the reverse of those above described; the suckers appear first, then the body shortens and becomes broader, the vibratile cilia are gradually retracted and the body rounded, and in about twenty minutes the animal resumes its globular form with its surface covered with long suckers. The same individuals passed several times through this series of metamorphoses. M. Maupas regards *Podophrya* as an intermediate type uniting the Infusoria Suctoria with the Ciliata.

Commensalism in Caterpillars.—Dr. Fritz Müller describes a curious instance of commensalism in two larvæ of some unknown Lepidoptera. He says the larger caterpillar, which has a red head, and is protected from enemies by long, branched, white stinging hairs, lives on mulberry and other trees. Like other protected caterpillars it is light-coloured and sits on the upper surface of the leaves. The second caterpillar is a little blackish fellow, and lies across the back of his larger companion, concealed among the stinging spine-like hairs of the latter. When taken off he went back to his original place immediately. In order to photograph the two animals Dr. Fritz Müller stupefied the large one with æther, which caused its death in about two days. The smaller caterpillar then quitted his post, and took up his abode on a second specimen, the place that he had occupied on his former host, having a pale and worn appearance. The smaller caterpillar stretches down from his position of vantage among the spines of the larger, and eats little holes in the leaf on which the latter rests.—*Zool. Garten*, 1877, p. 67.

Fauna of Lake Gokcha.—The study of the faunas of isolated sheets of water promises to furnish some of the most striking direct confirmations of the theory of the origin of species by descent with modification, and all records of such investigations must be regarded as of much importance. Lake Gokcha, on the fauna of which Professor Kessler has lately published a memoir in the "Memoirs of the Society of Naturalists of St. Petersburg," is one of these interesting localities, being situated in the Caucasus, at a height of 6,419 ft., and entirely surrounded by lofty mountains, through which only a small river carries off its surplus waters. Its surface occupies about 660 square miles, and its general depth varies between 150 and 250 ft., but in one part it reaches 361 ft. In this lake Professor Kessler found *Spongillæ* to be exceedingly abundant. The commonest worm is *Nephelis vulgaris*; the crustacea are represented by numerous Entomostraca, and by a single species of *Gammarus*; the Gasteropod mollusca are all well-known European species (*Limnæus stagnalis*, *ovatus* and *auricularius* and *Planorbis carinatus*); and the *Bufo viridis* and a local variety of the

common frog abound. With the fishes the case is somewhat different, and this fact is interesting in connection with the recent observations of M. Victor Fatio on certain species of fish in the Swiss lakes. Although the lakes swarm with fish, these belong only to five species, three of which, pertaining to the genus *Salmo*, are regarded by Professor Kessler as new, although allied to or intermediate between the well-known European species *Salmo fario*, *S. trutta*, and *S. lacustris*. Professor Kessler proposes to name them *Salmo ischan*, *hegarcuni*, and *bodschac*. Of the other two species, one very closely resembles *Capoëta fundula* Pallas, a Central Asiatic species; and the other most nearly approaches *Barbus Cyri*, de' Filippi. The last-named species inhabits the streams flowing into the lake from the mountains.

Demodex folliculorum.—Whether Butler's reference to the "maggot in cheesemonger's nose" is to be taken as evidence that the philosophers of his day had any knowledge of the existence of the curious parasite in the follicles of the human skin to which the above name has been given, is a question that we may leave to the learned in such matters, who may at the same time settle whether cheesemongers are more subject than other men to the peculiar pimples which betray the presence of the parasite. Our first definite knowledge of it is due to Dr. Simon, of Berlin, who discovered it in 1842, by the assistance of Erichson recognized its affinity to the mites (the group to which the itch-parasite also belongs), and described it pretty fully under the name of *Acarus folliculorum*. Professor Owen, in 1843, founded a new genus for the reception of the parasite, and called it *Demodex*; Erasmus Wilson, who regarded it as a worm, named its genus *Entozoon*; M. Paul Gervais, in ignorance of Professor Owen's name, gave it the generic name of *Simonea*; and M. Miescher, changing both names, christened it *Macrogaster platypus*. M. P. Mégnin, a well-known student of the Acarina, has just published (in the "Journal de l'Anatomie et de la Physiologie," 1877, No. 2) a long and interesting memoir upon *Demodex folliculorum*, containing a history of our knowledge of the animal, a discussion of its zoological affinities, a full description of its structure, and an account of its development and habits. Like its discoverer and most of the zoologists who have described it, he refers it to the order of Mites (*Acarina*), and, following M. Paul Gervais, he regards it as forming a distinct family (*Demodicidæ*) in that order, nearly related to the Bear Animalcules (*Arctisca* or *Tardigrada*), so well known to all microscopists, on account of their wonderful faculty of coming to life again after desiccation.

These creatures are minute, somewhat worm-like parasites, from $\frac{1}{120}$ to about $\frac{1}{60}$ inch in length, having a more or less oval cephalothorax, bearing in front a sort of rostrum composed of mandibles, maxillæ, palpi, and ligula, and along its sides four pairs of short, three-jointed feet, each furnished with a pair of blunt claws. Behind this part comes a thinner, finely-ringed abdomen, variable in length, but usually longer than the cephalothorax. The little animals are found in the sebaceous and hair follicles of the skin in man and some animals. They are said by M. Mégnin to be viviparous, the females producing small footless, contractile larvæ, without any mouth organs; these, shortly after their birth, acquire three pairs of conical tubercles, which serve them as feet for creeping about. A change of skin

converts these larvæ into pupæ of similar form, but having four pairs of papilliform feet, and showing traces of the rostrum. After a second change the perfect *Demodex* is produced, but still without the sexual organs, which make their appearance subsequently. M. Mégnin distinguishes three if not four forms of these parasites, which, however, he prefers to regard for the present as varieties of a single species, *Demodex folliculorum*. The commonest of these appears to be that of the dog (var. *caninus*), which inhabits the hair-follicles of all parts of the body of that animal. A smaller variety (*cati*) is found almost solely in the sebaceous glands of the ear of the cat; and a larger one (var. *hominis*) in the follicles of the human face. M. Simon also met with similar parasites in the glands of the margin of the eyelids in sheep (var. *ovis*), but no other writer has ever seen them there. In the dog the presence of these parasites, which occur in great numbers together in the hair follicles, produces a regular skin disease, or mange, but this does not appear to be transmissible to the human subject.

Intelligence of Ants.—Sir John Lubbock has communicated to the Linnean Society, a fourth part of his "Contributions on the habits of Ants, Bees, and Wasps," in which he describes the results of numerous ingenious experiments made to test the intelligence of various species of the first-named group. Individuals of *Lasius niger*, engaged in fetching larvæ out of a small glass cell, in which they passed over a somewhat complicated bridge, were at once stopped in their proceedings by the interposition of a small gap of only $\frac{3}{10}$ inch; they had not sufficient intelligence to drop this short distance, unless indeed they were deterred by prudential considerations as to the possibility of getting back, nor did those below adopt the apparently easy method of crowding upon each other to the required height to re-establish the broken communication. As an example of conscientious industry, Sir John cited the case of an individual ant, which he was in the habit of shutting up in a bottle before leaving home for the day; the little prisoner when released immediately commenced work, and even a week's imprisonment had no effect upon its zeal. From some experiments, it appears that ants when in difficulties in sight of their companions are by no means always assisted or relieved, and this is especially the case when the charms of a store of honey or other food come into competition with the promptings of the benevolent instincts. Individuals under the influence of chloroform were generally passed without notice, but sometimes even their friends would push them out of the way; the general practice was to let friends lie, but to drop strangers over the edge of the board. Intoxicated ants appeared to be a puzzle to their friends, who, however, generally picked them up and carried them into the nest; but strangers in the same condition were not so kindly used, they were thrown into the water and drowned. Sometimes mistakes occurred, strangers were carried into the nest, and friends thrown into the water; no attempts were made to save the latter, but the strangers were generally detected and ignominiously dragged out of the nest again. From various experiments it appeared that the ants of an entire nest know and recognize each other; indeed even after a year's absence, old companions are recognized and amicably received, whereas strangers are almost invariably attacked and maltreated, even when mixed with old friends. In this respect, however, different species show differences of character; *Lasius*

flavus behaves as above described, but *Formica fusca* is much milder and more courteous in its demeanour towards strangers. Some of the experiments seem to show that the sense of sight is not very acute in certain species of ants. Thus, food was placed a few inches from the nest on a glass slip, the straight road to and from which was soon learned, but when the food was shifted only a short distance from its original position, the same individual ants wandered about in a circuitous path for several minutes and sometimes for half an hour, before discovering the new locality of the food. Sir John Lubbock confirms the statements of former writers as to slavery being a regular institution with some genera of ants, and states that the Amazon ants (*Polyergus rufescens*) absolutely require a slave attendant to clean and feed them. Some of his experiments seemed to prove that these aristocratic ants would rather die than help themselves. The author also referred to certain parasites on ants and in ants' nests.

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(FIG. 2.)

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FIG. 3.

FIG. 4.

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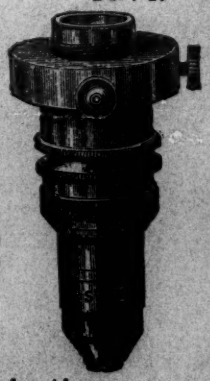
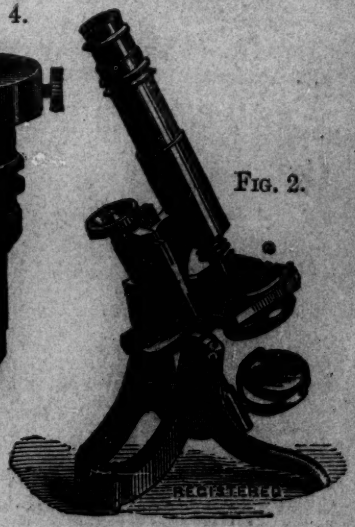


FIG. 2.



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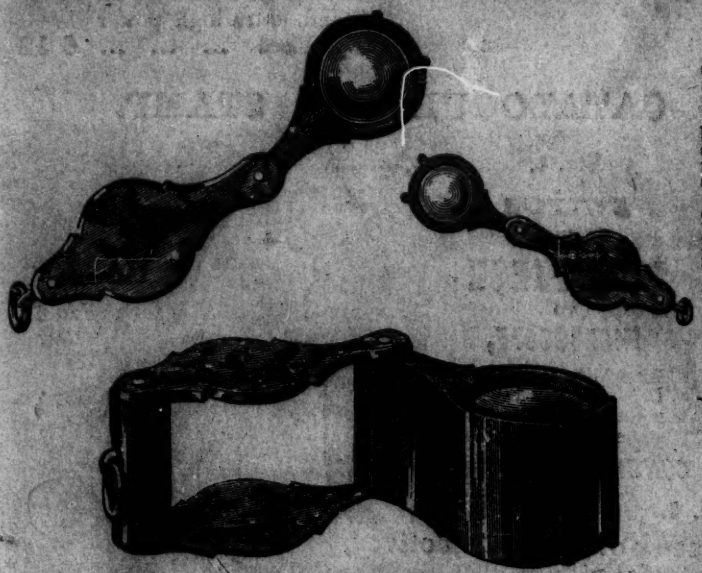

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